5

ENGINEERING CHANGE NOTICE

1. ECN 653552

Proj. ECN

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.	4. USQ Required?	5. Date
Supplemental [] Direct Revision [X] Change ECN [] Temporary [] Standby [] Supersedure [] Cancel/Void []	Jim G. Field, Data Assessment and Interpretation, R2-12, 376-3753	[] Yes [X] No	03/23/99
	6. Project Title/No./Work Order No. Tank 241-SX-115	7. Bldg./Sys./Fac. No. 241-SX-115	8. Approval Designator N/A
	9. Document Numbers Changed by this ECN (includes sheet no. and rev.) HNF-SD-WM-ER-684, Rev. 0-A	10. Related ECN No(s). N/A	11. Related PO No. N/A

12a. Modification Work	12b. Work Package No.	12c. Modification Work Complete	12d. Restored to Original Condition (Temp. or Standby ECN only)
[] Yes (fill out Blk. 12b) [X] No (NA Blks. 12b, 12c, 12d)	N/A	N/A Design Authority/Cog. Engineer Signature & Date	N/A Design Authority/Cog. Engineer Signature & Date

13a. Description of Change   13b. Design Baseline Document? [] Yes [X] No

The document has been totally revised to include the results of recent sampling to address technical issues associated with the waste, and to update the best basis standard inventory.

14a. Justification (mark one)

Criteria Change	[X]	Design Improvement	[]	Environmental	[]	Facility Deactivation	[]
As-Found	[]	Facilitate Const	[]	Const. Error/Omission	[]	Design Error/Omission	[]

14b. Justification Details

Changes required to incorporate new sampling data.

15. Distribution (include name, MSIN, and no. of copies)

See attached distribution.

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16. Design Verification Required	17. Cost Impact				18. Schedule Impact (days)	
	ENGINEERING		CONSTRUCTION			
[] Yes	Additional	[] $	Additional	[] $	Improvement	[]
[X] No	Savings	[] $	Savings	[] $	Delay	[]

19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.

SDD/DD	[]	Seismic/Stress Analysis	[]	Tank Calibration Manual	[]
Functional Design Criteria	[]	Stress/Design Report	[]	Health Physics Procedure	[]
Operating Specification	[]	Interface Control Drawing	[]	Spares Multiple Unit Listing	[]
Criticality Specification	[]	Calibration Procedure	[]	Test Procedures/Specification	[]
Conceptual Design Report	[]	Installation Procedure	[]	Component Index	[]
Equipment Spec.	[]	Maintenance Procedure	[]	ASME Coded Item	[]
Const. Spec.	[]	Engineering Procedure	[]	Human Factor Consideration	[]
Procurement Spec.	[]	Operating Instruction	[]	Computer Software	[]
Vendor Information	[]	Operating Procedure	[]	Electric Circuit Schedule	[]
OM Manual	[]	Operational Safety Requirement	[]	ICRS Procedure	[]
FSAR/SAR	[]	IEFD Drawing	[]	Process Control Manual/Plan	[]
Safety Equipment List	[]	Cell Arrangement Drawing	[]	Process Flow Chart	[]
Radiation Work Permit	[]	Essential Material Specification	[]	Purchase Requisition	[]
Environmental Impact Statement	[]	Fac. Proc. Samp. Schedule	[]	Tickler File	[]
Environmental Report	[]	Inspection Plan	[]		[]
Environmental Permit	[]	Inventory Adjustment Request	[]		[]

20. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision
N/A		

21. Approvals

	Signature	Date		Signature	Date
Design Authority			Design Agent		
Cog. Eng. J.G. Field	J G Field	3/24/99	PE		
Cog. Mgr. K.M. Hall	Kathleen M. Hall	3/26/99	QA		
QA			Safety		
Safety			Design		
Environ.			Environ.		
Other J.W. Cammann	JW Cammann	3/24/99	Other		
R.J. Cash	R J Cash	3/26/99	DEPARTMENT OF ENERGY Signature or a Control Number that tracks the Approval Signature		
			ADDITIONAL		

S

Tank Characterization Report for Single-Shell Tank 241-SX-115

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Abstract: This document summarizes the information on the historical uses, present status, and the sampling and analysis results of waste stored in Tank 241-SX-115. This report supports the requirements of the Tri-Party Agreement Milestone M-44-15C.

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(2) Title

Preliminary Tank Characterization Report for Single-Shell Tank 241-SX-115: Best-Basis Inventory

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Revision 1

Tank Characterization Report for Single-Shell Tank 241-SX-115

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LIST OF TERMS

ALARA	as low as reasonably achieveable
ANOVA	analysis of variance
Btu/hr	British thermal units per hour
Ci	curie
Ci/L	curies per liter
CI	confidence interval
cm	centimeter
c/s	counts per second
DQO	data quality objective
DSC	differential scanning calorimetry
ft	feet
g/L	grams per liter
g/mL	grams per milliliter
g/mole	grams per mole
HDW	Hanford defined waste
HLW	high-level waste
IC	ion chromatography
ICP	inductively coupled plasma spectroscopy
in.	inch
J/g	joules per gram
Kg	kilogram
kgal	kilogallon
kL	kiloliter
kW	kilowatt
LEL	lower explosive limit
LFL	lower flammability limit
L/gal	liters per gallon
LL	lower limit
m	meter
M	moles per liter
n/a	not applicable
n/r	not reported
PHMC	Project Hanford Management Contractor
ppm	parts per million
QC	quality control
REDOX	Reduction and Oxidation process

LIST OF TERMS (Continued)

REML	restricted maximum likelihood
R	REDOX process high-level waste
R1	REDOX waste 1952-58
R2	REDOX waste 1959-66
RPD	relative percent difference
RSltCk	REDOX saltcake
SAP	sampling and analysis plan
SMM	supernatant mixing model
TCR	tank characterization report
TGA	thermogravimetric analysis
TIC	total inorganic carbon
TLM	tank layer model
TOC	total organic carbon
TWRS	Tank Waste Remediation System
UL	upper limit
W	watt
WSTRS	Waste Status and Transaction Record Summary
wt%	weight percent
°C	degrees Celsius
°F	degrees Fahrenheit
µCi/g	microcuries per gram
µCi/mL	microcuries per milliliter
µCi/L	micro curies per liter
µeq/g	microequivalents per gram
µg	microgram
µg C/g	micrograms of carbon per gram
µg/g	micrograms per gram

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1.0 INTRODUCTION

A major function of the Tank Waste Remediation System (TWRS) is to characterize waste in support of waste management and disposal activities at the Hanford Site. Analytical data from sampling and analysis and other available information about a tank are compiled and maintained in a tank characterization report (TCR). This report and its appendices serve as the TCR for single-shell tank 241-SX-115.

The objectives of this report are 1) to use characterization data in response to technical issues associated with tank 241-SX-115 waste, and 2) to provide a standard characterization of this waste in terms of a best-basis inventory estimate. Section 2.0 summarizes the response to technical issues, Section 3.0 shows the best-basis inventory estimate, Section 4.0 makes recommendations about the safety status of the tank and additional sampling needs. The appendices contain supporting data and information. This report supports the requirements of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1997), Milestone M-44-15c, change request M-44-97-03 to "issue characterization deliverables consistent with the Waste Information Requirements Document developed for FY 1999" (Adams et al. 1998).

1.1 SCOPE

The characterization information in this report originated from sample analyses and known historical sources. Samples were obtained and assessed to fulfill requirements for tank specific issues discussed in Section 2.0 of this report. Other information was used to support conclusions derived from these results. Appendix A contains historical information for tank 241-SX-115 including surveillance information, records pertaining to waste transfers and tank operations, and expected tank contents derived from a process knowledge model. Appendix B summarizes recent sampling events (see Table 1-1), sample data obtained before 1989, and sampling results. Appendix C provides the statistical analysis and numerical manipulation of data used in issue resolution. Appendix D contains the evaluation to establish the best basis for the inventory estimate. Appendix E is a bibliography that resulted from an in-depth literature search of all known information sources applicable to tank 241-SX-115 and its respective waste types.

Table 1-1. Summary of Recent Sampling.

Sample/Date[1]	Phase	Location	Segmentation	% Recovery
Combustible gas measurement (3/8/96 and 3/13/98)	Gas	Tank headspace, Riser 6, 6.1 m (20 ft) below top of riser	n/a	n/a
Surface finger trap grab (3/13/98)	Solid	Riser 6	Composite	n/a (78 g)

Notes:

n/a = not applicable

[1]Dates are in the mm/dd/yy format.

1.2 TANK BACKGROUND

Tank 241-SX-115 is located in the SX Tank Farm in the 200 West Area of the Hanford Site. The tank went into service in 1958 and was used as a receiving tank for the reduction and oxidation process (REDOX) high-level waste through 1960. From 1960 to 1964, supernatant liquids and condensate were transferred into and out of tank 241-SX-115 from various tanks within the 241-SX Tank Farm. In addition, waste was transferred to the 202-S Plant for processing. The supernatant was pumped in 1965 to remove the remaining liquids from tank 241-SX-115 because of a confirmed leak (WHC 1992). Tank 241-SX-115 was removed from service in 1965 and interim stabilized in 1978. Intrusion prevention (interim isolation) was completed in December 1982 (Brevick et al. 1997).

Table 1-2 is an overall description of tank 241-SX-115. The tank has a maximum storage capacity of 3,785 kL (1,000 kgal) and presently contains an estimated 45.4 kL (12 kgal) of noncomplexed waste (Hanlon 1999). The tank is not on the Watch List (Public Law 101-510).

Table 1-2. Description of Tank 241-SX-115.

TANK DESCRIPTION	
Type	Single-shell
Constructed	1954
In-service	1958
Diameter	22.9 m (75 ft)
TANK DESCRIPTION	
Operating depth	9.24 m (30.3 ft)
Design capacity	3,785 kL (1,000 kgal)
Bottom shape	Dish
Ventilation	Passive
TANK STATUS (11/30/98)	
Waste classification	Non-complexed
Total waste volume	45.4 kL (12 kgal)
Supernate volume	0 kL (0 kgal)
Saltcake volume	0 kL (0 kgal)
Sludge volume	45.4 kL (12 kgal)
Drainable interstitial liquid volume	0 kL (0 kgal)
Waste surface level (10/17/98)[1]	15.9 cm (6.25 in.)
Temperature	N/A
Integrity	Assumed leaker
Watch list status	None
Flammable gas facility group	3
SAMPLING DATES	
Headspace combustible gas measurements	March 1996 March 1998
Grab samples	March 1998
SERVICE STATUS	
Declared inactive	1965
Interim stabilization	1978
Intrusion prevention	1982

Note:

N/A = not available

[1]Last surface level measurements before 11/30/98. This surface level is 8.5 cm (3.35 in.) lower than the 24.4 cm (9.6 in.) expected for the equivalent Hanlon (1999) volume of 45.4 kL (12 kgal). This measured level is lower because of a plummet contacting solids in a hole it has created in the waste surface (Swaney 1993).

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2.0 RESPONSE TO TECHNICAL ISSUES

No technical issues were identified for tank 241-SX-115 in revision 4 of the *Tank Characterization Technical Sampling Basis* (Brown et al. 1998). Revision 3 (Brown et al. 1997) identified the following technical issues:

- **Safety screening**: Does the waste pose or contribute to any recognized potential safety problems?
- **Organic complexants**: Does the possibility exist for a point source ignition in the waste followed by a propagation of the reaction in the solid/liquid phase of the waste?
- **Organic solvents**: Does an organic solvent pool exist that may cause a fire or ignition of organic solvents in entrained waste solids?

Three surface finger trap grab samples were taken during March 1998 in accordance with the *Tank 241-SX-115 Grab Sampling and Analysis Plan* (Simpson 1998a). The grab samples were analyzed according to *Modifications to 241-SX-115 Sample Handling and Analysis* (Simpson 1998b). All three samples were combined to form a single composite. Sample handling, descriptions and analytical results for the grab samples are reported in Esch (1998) and detailed in Appendix B of this TCR.

Data from the analysis of the finger trap grab samples taken in 1998, along with available historical information and tank headspace measurements, provided the means to respond to the technical issues. The following sections present the response to the technical issues.

2.1 SAFETY SCREENING

The data needed to screen the waste in tank 241-SX-115 for potential safety problems are documented in *Tank Safety Screening Data Quality Objective*, (Dukelow et al. 1995). These potential safety problems are exothermic conditions in the waste, flammable gases in the waste and/or tank headspace, and criticality conditions in the waste. Each condition is addressed separately below.

The safety screening data quality objective (DQO) requires that two vertical profiles of the waste be obtained in order to perform the safety screening assessment. The finger trap grab sampling method only captured the material from the waste surface. Although the waste depth is minimal (approximately 24.4 cm [9.6 in]), a full-depth profile was not obtained. However, because the tank waste is believed to be composed of REDOX high-level waste (HLW) sludge, material from the waste surface should reasonably represent the entire waste profile. Therefore, the sampling performed is considered adequate for performing a safety screening assessment.

2.1.1 Exothermic Conditions (Energetics)

The first requirement outlined in the safety screening DQO (Dukelow et al. 1995) is to ensure there are not sufficient exothermic constituents (organic or ferrocyanide) in tank 241-SX-115 to pose a safety hazard. The safety screening DQO required the waste sample profile be tested for energetics every 24 cm (9.5 in.) to determine whether the energetics exceeded the safety threshold limit. The threshold limit for energetics is 480 J/g on a dry weight basis.

A total organic carbon (TOC) analysis by furnace oxidation was requested to replace the differential scanning calorimetry (DSC) analysis for energetics, because of radiological control and as low as reasonably achieveable (ALARA) concerns (Simpson 1998b). Because no ferrocyanide is expected in the tank based on the process history, TOC would be the source of any energetics. A TOC analysis provides sufficient information in regards to waste energetics. Results obtained from TOC analysis indicated that no organic carbon was detected in the composite sample. The standards and spikes of the TOC analyses were within required limits. Therefore, energetic behavior from TOC is not a concern for this tank.

2.1.2 Flammable Gas

Headspace measurements using a combustible gas meter were taken from riser 6 on March 13, 1998, before the finger trap grab samples were taken. Flammable gas was not detected in the tank headspace (0 percent of the lower flammability limit [LFL] before grab sampling). Results from a prior vapor sampling event March 8, 1996, headspace measurements yielded values of < 1 % of the lower flammability limit (LFL). Both of these results are below the safety screening limit of 25 percent of the LFL. Data for the vapor phase measurements are presented in Appendix B.

2.1.3 Criticality

The safety screening DQO threshold for criticality, based on total alpha activity, is 1 g/L. Because total alpha activity is measured in μCi/g instead of g/L, the 1g/L limit is converted into units of μCi/g by assuming that all alpha decay originates from ^{239}Pu. The safety threshold limit is 1 g ^{239}Pu per liter of waste. Assuming that all alpha is from ^{239}Pu and using the Hanford defined waste (HDW) model density value of 1.73 g/mL, 35.5 μCi/g is the safety screening limit for alpha activity. The average sample result for ^{239}Pu analyses was 19.9 μCi/g. The upper limit to the 95 percent confidence interval calculated on that mean was 22.1 μCi/g. Because all of the ^{239}Pu results were below the 35.5 μCi/g threshold, criticality is not a concern for this tank. If total alpha activity had included the value for ^{241}Am (14.1 μCi/g), then the upper limit for the 95 percent confidence level would have exceeded the safety screening threshold. However, because the true radionuclide of concern regarding criticality is ^{239}Pu and all of the $^{239/240}$Pu results were below safety screening limits, criticality is not a concern. Appendix C contains the method used to calculate confidence limits for safety screening.

2.2 ORGANIC COMPLEXANTS

The data required to support the organic complexants issue are documented in *Memorandum of Understanding for the Organic Complexant Safety Issue Data Requirements* (Schreiber 1997). Usually energetics by DSC and sample moisture analysis by thermogravimetry are conducted to address the organic complexants issue. However, because of the high dose rates associated with the samples, the DSC analysis was replaced by a furnace oxidation TOC and the thermogravimetric analysis was replaced by a gravimetric analysis. The moisture content data are needed only for converting the TOC values to a dryweight basis.

As discussed in Section 2.1.1, energetics is not a concern for tank 241-SX-115 because all TOC values were less than the detection limits. The standard and spike recoveries were within the required limits, no confidence intervals or dry weight values were calculated, and the probability of a propagating event is not a concern for this tank. Therefore, the tank is classified as "safe" for this issue.

The organic complexant safety issue was closed in December 1998 (Owendoff 1998).

2.3 ORGANIC SOLVENTS SAFETY SCREENING

The data required to support the organic solvent screening issue are documented in the *Data Quality Objective to Support Resolution of the Organic Solvent Safety Issue* (Meacham et al. 1997). The DQO requires tank headspace samples be analyzed for total nonmethane organic compounds to determine whether the organic extractant pool in the tank is a hazard. The purpose of this assessment is to ensure that an organic solvent pool fire or ignition of organic solvents cannot occur.

No vapor samples have been taken to estimate the organic pool size. However, the organic program has determined that even if an organic pool does exist, the consequence of a fire or ignition of organic solvents is below risk evaluation guidelines for all of the tanks (Brown et al. 1998). Consequently, vapor samples are not required for this tank. The organic solvent safety issue is expected to be closed in 1999.

2.4 OTHER TECHNICAL ISSUES

2.4.1 Hazardous Vapor Screening

Vapor samples have not been taken to address requirements of *Data Quality Objectives for Tank Hazardous Vapor Safety Screening* (Osborne and Buckley 1995). Hazardous vapor screening is no longer an issue because headspace vapor (sniff) tests are required for the safety screening DQO (Dukelow et al. 1995), and the toxicity issue was closed for all tanks (Hewitt 1996).

2.4.2 Tank Waste Heat Load

A factor in assessing tank safety is the heat generation and temperature of the waste. Heat is generated in the tanks from radioactive decay. An estimate of the tank heat load based on the 1998 sample event was not possible because radionuclide analyses used to estimate heat load were not performed. The heat load estimate based on the tank process history was 0.223 kW (760 Btu/hr) (Agnew et al. 1997). An estimate for heat load based on the best basis inventory is 2.720 kW (9,260 Btu/hr), more than ten times the estimate based on the process history. Both estimates are well below the limit of 11,700 W (40,000 Btu/hr) that separates high- and low-heat-load tanks (Smith 1986). Kummerer (1995) did not estimate the heat load based on the tank headspace temperatures because of the lack of temperature data.

Table 2-1. Tank 241-SX-115 Projected Heat Load[1]

Radionuclide	Curies	Watts
^{241}Am	1,100	36.1
^{239}Pu	1,360	41.5
^{240}Pu	199	6.1
^{90}Sr	382,000	2,560
^{137}Cs	16,300	77
Total Watts		2,720

Note:
[1]Based on best basis inventory estimates, see Section D, Table D4-2.

2.5 SUMMARY

The results of all analyses performed to address potential safety issues showed that primary analytes did not exceed safety decision threshold limits. A vertical profile of the waste from two risers was not obtained. There is no indication that any waste type other than REDOX high-level sludge exists in the tank. Samples of the waste surface should represent conditions throughout the waste depth, therefore the intent of the safety screening DQO was met. A summary of the technical issues is presented in Table 2-2.

Table 2-2. Summary of Technical Issues.

Issue	Sub-issue	Result
Safety screening	Energetics	All TOC results were below detection limits.
	Flammable gas	Headspace measurements of March 1996 March 1998 were < 1% of the LFL (combustible gas meter)
	Criticality	All $^{239/240}Pu$ results and 95% confidence interval upper limits were below 35.5 μCi/g.
Organic complexants[1]	Safety categorization (Safe)	All TOC results were below detection limits.
Organic solvents[2]	Solvent pool size	No vapor samples to estimate the pool size have been taken. Because the consequence of a fire or ignition of organic solvents is below risk evaluation guidelines for all of the tanks, no vapor samples are required.

Notes:

[1]The organic complexant safety issue was closed in December 1998 (Owendoff 1998).

[2]The organic solvent safety issue is expected to be closed in 1999.

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3.0 DEFINE THE BEST-BASIS AND ESTABLISH COMPONENT INVENTORIES

Tank farm activities include overseeing tank farm operations and identifying, monitoring, and resolving safety issues associated with these operations and with the tank wastes. Disposal activities involve designing equipment, processes, and facilities for retrieving wastes and processing them into a form that is suitable for long-term storage/disposal. Information about chemical, radiological, and/or physical properties is used to perform safety analyses, engineering evaluations, and risk assessment work associated with tank farm operation and disposal.

Chemical and radiological inventory information are generally derived using three approaches: 1) component inventories are estimated using the results of sample analyses, 2) component inventories are predicted using the HDW Model based on process knowledge and historical information, or 3) a tank-specific process estimate is made based on process flow sheets, reactor fuel data, essential material usage, and other operating data.

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of chemical information for tank 241-SX-115 was performed, and a best basis inventory was established. This work follows the methodology that was established by the standard inventory task. The following information was utilized as part of this evaluation:

- Limited analytical results from a 1975 sludge sampling (Horton 1975)
- Limited analytical results from the 1998 finger trap grab sampling (Esch 1998)
- Inventory estimates generated by HDW model (Agnew et al. 1997)
- Average of analyte concentrations in REDOX process HLW for auger 95-AUG-043 from tank 241-SX-108 (Hendrickson 1998)
- Average of analyte concentrations in REDOX process HLW sludges in tanks 241-S-101 (Kruger et al. 1996), 241-S-104 (DiCenso et al. 1994), and 241-S-107 (Simpson et al. 1996)
- Inventory estimates generated by a tank-specific assessment process utilizing chemical process flow sheets and a detailed historical waste transaction data base.

Because the vast majority of the waste constituents were not analyzed on the 1998 samples, an alternative method of deriving inventories was required. The results from the evaluation presented in this appendix support using a predicted inventory based primarily on data from auger 95-AUG-043 of tank 241-SX-108 for the following reasons:

1. Based upon a comprehensive review of historical waste transaction records, it is believed that only the REDOX process HLW introduced into tank 241-SX-115 contributed to the solid waste currently in the tank.

2. The HDW model incorrectly attributes part of the solids now in tank 241-SX-115 to saltcake precipitated from one addition of concentrated REDOX process HLW supernatant.

3. Many uncertainties exist regarding the quality of the 1975 data for tank 241-SX-115.

The waste in tank 241-SX-108 originated from the same REDOX processes as that in tank 241-SX-115, and both tanks shared similar process histories (self-boiling). The analytical data from auger 95-AUG-043 of tank 241-SX-108 more closely matches the available tank 241-SX-115 analytical values than the previous best-basis estimates or the HDW Model values.

For the few analytes that had results from the 1975 sample but no corresponding tank 241-SX-108 data, the 1975 values were used to derive the inventory. Model numbers were used when there were no analytical values, or the analytical values were large non-detects.

Best-basis tank inventory values are derived for 46 key radionuclides (as defined in Section 3.1 of Kupfer et al. 1998), all decayed to a common report date of January 1, 1994. Often, waste sample analyses have only reported ^{90}Sr, ^{137}Cs, $^{239/240}$Pu, and total uranium (or total beta and total alpha), while other key radionuclides such as ^{60}Co, ^{99}Tc, ^{129}I, ^{154}Eu, ^{155}Eu, and ^{241}Am, etc., have been infrequently reported. For this reason, it has been necessary to derive most of the 46 key radionuclides by computer models. These models estimate radionuclide activity in batches of reactor fuel, account for the split of radionuclides to various separations plant waste streams, and track their movement with tank waste transactions. (These computer models are described in Kupfer et al. 1998, Section 6.1 and in Watrous and Wootan 1997.) Model generated values for radionuclides in any of 177 tanks are reported in the HDW Rev. 4 model results (Agnew et al. 1997). The best-basis value for any one analyte may be either a model result or a sample or engineering assessment-based result, if available.

The inventory values reported in Tables 3-1 and 3-2 are subject to change. Refer to the Tank Characterization Database (LMHC 1999) for the most current inventory values.

Table 3-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-SX-115 (Effective January 20, 1999).

Analyte	Total Inventory (kg)	Basis (S, M, E, or C)[1]	Comment
Al	4,110	E	Horton (1975) = 3,860 kg
Bi	4.37	E	
Ca	207	E	Horton (1975) = 619 kg
Cl	211	E	
TIC as CO_3	411	M	
Cr	801	E	
F	54.0	E	
Fe	2,000	E	Horton (1975) = 4,160 kg
Hg	0	E	Simpson 1998c
K	73.3	E	
La	14.1	E	
Mn	702	E	Horton (1975) = 998 kg
Na	12,000	E	Horton (1975) = 2,000 kg
Ni	137	E	
NO_2	864	E	Horton (1975) = 167 kg
NO_3	13,600	E	
OH_{TOTAL}	16,000	C	
Pb	27.5	E	
PO_4	27.2	E	Based on ICP
Si	128	E	Horton (1975) = 765 kg
SO_4	357	E	Based on IC
Sr	65.4	E	
TOC	88.0	S/E	Upper bounding estimate; 1998 result
U_{TOTAL}	598	E	
Zr	50.0	E	

Note:

TIC = total inorganic carbon
ICP = inductively coupled plasma spectroscopy
IC = ion chromatography

[1]S = sample-based; M = Hanford defined waste model-based (Agnew et al. [1997]); E = engineering assessment-based; C = calculated by charge balance; includes oxides as hydroxides, not including CO_3, NO_2, NO_3, PO_4, SO_4, and SiO_3.

Table 3-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-SX-115 Decayed to January 1, 1994 (Effective January 20, 1999). (2 sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{3}H	5.73	M	
^{14}C	0.311	M	
^{59}Ni	0.492	M	
^{60}Co	122	S	Horton (1975)
^{63}Ni	46.5	M	
^{79}Se	0.169	M	
^{90}Sr	3.82E+05	E	Horton (1975) = 1.39E+06 Ci
^{90}Y	3.82E+05	E	Referenced to ^{90}Sr
^{93}Zr	0.798	M	
^{93m}Nb	0.648	M	
^{99}Tc	2.38	M	
^{106}Ru	5.41E-05	M	
^{113m}Cd	1.21	M	
^{125}Sb	172	S	Horton (1975)
^{126}Sn	0.259	M	
^{129}I	0.00452	M	
^{134}Cs	3.32	S	Horton (1975)
^{137}Cs	16,300	E	Horton (1975) = 2,070 Ci
^{137m}Ba	15,400	E	Referenced to ^{137}Cs
^{151}Sm	602	M	
^{152}Eu	0.360	M	
^{154}Eu	920	S	Horton (1975)
^{155}Eu	880	E	Upper bounding estimate; Based on tank 241-SX-108 data
^{226}Ra	3.52E-05	M	
^{227}Ac	1.71E-04	M	
^{228}Ra	3.58E-04	M	
^{229}Th	8.62E-06	M	
^{231}Pa	2.51E-04	M	
^{232}Th	4.79E-06	M	
^{232}U	0.0116	E/M	Based on total uranium and HDW isotopic distribution

Table 3-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-SX-115 Decayed to January 1, 1994 (Effective January 20, 1999). (2 sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{234}U	0.228	E/M	Based on total uranium and HDW isotopic distribution
^{235}U	0.00928	E/M	Based on total uranium and HDW isotopic distribution
^{236}U	0.00896	E/M	Based on total uranium and HDW isotopic distribution
^{237}Np	0.0111	M	
^{238}Pu	22.3	S/M	Based on ^{239}Pu data and HDW isotopic distribution
^{238}U	0.200	E/M	Based on total uranium and HDW isotopic distribution
^{239}Pu	1,360	S/M	Based on 1998 $^{239/240}Pu$ data and HDW isotopic distribution
^{240}Pu	199	S/M	Based on 1998 $^{239/240}Pu$ data and HDW isotopic distribution
^{241}Am	1,110	S	1998 result
^{241}Pu	1,290	S/M	Based on ^{239}Pu data and HDW isotopic distribution
^{242}Cm	1.45	S/M	Based on ^{241}Am data and HDW isotopic distribution
^{242}Pu	0.00612	S/M	Based on ^{239}Pu data and HDW isotopic distribution
^{243}Am	0.0338	S/M	Based on ^{241}Am data and HDW isotopic distribution
^{243}Cm	0.0331	S/M	Based on ^{241}Am data and HDW isotopic distribution
^{244}Cm	0.0257	S/M	Based on ^{241}Am data and HDW isotopic distribution

Note:

[1]S = sample-based; M = Hanford defined waste model-based (Agnew et al. [1997]); E = engineering assessment-based.

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4.0 RECOMMENDATIONS

The results of all analyses performed to address the safety screening DQO showed that the TOC concentration, headspace flammable gas concentration, and the $^{239/240}Pu$ activity did not exceed their respective safety decision threshold limits. The organic complexant issue, which is now closed (Owendoff 1998) is addressed by measuring energetics and moisture. Although moisture content in the tank was measured at 10.1 wt %, the TOC concentration was found to be less than the detection limit. As a result, energetics is not a problem, and the tank is classified as safe for the organic complexants issue. No vapor samples have been taken to estimate the organic pool size. However, the Organic Program has determined that even if an organic pool does exist, the consequence of a fire or ignition of organic solvents is below risk evaluation guidelines for all of the tanks (Brown et al. 1998). The organic solvent safety issue is expected to be closed in 1999.

Table 4-1 summarizes the Project Hanford Management Contractor (PHMC) TWRS Program review status and acceptance of the sampling and analysis results reported in this TCR. All issues required to be addressed by sampling and analysis are listed in column 1 of Table 4-1. Column 2 indicates by "yes" or "no" whether issue requirements were met by the sampling and analysis performed. Column 3 indicates concurrence and acceptance by the program in PHMC/TWRS that is responsible for the applicable issue. A "yes" in column 3 indicates that no additional sampling or analyses are needed. Conversely, a "no" indicates additional sampling or analysis may be needed to satisfy issue requirements.

Because the waste samples from the tank were very friable and exhibited higher than desired radioactivity, alternative analyses were performed (Simpson 1998b). The alternative analyses provided equivalent results, so a safety screening assessment was possible. As discussed in Section 2.0, although waste samples were obtained from the surface only, the samples are considered representative of the full waste profile and therefore, adequate for performing a safety screening assessment.

Table 4-1. Acceptance of Tank 241-SX-115 Sampling and Analysis.

Issue	Sampling and Analysis Performed	TWRS/PHMC Program Acceptance
Safety screening DQO (Dukelow et al. 1995)	Yes	Yes
Organic complexants MOU[1] (Schrieber 1997)	Yes	Yes
Organic solvents DQO[2] (Meacham et al. 1997)	No	n/a

Notes:

[1]The organic complexant safety issue was closed in December 1998 (Owendoff 1998).

[2]The organic solvent safety issue is expected to be closed in 1999.

Table 4-2 summarizes the status of PHMC TWRS Program review and acceptance of the evaluations and other characterization information contained in this report. Column 1 lists the different evaluations performed in this report. Column 2 shows whether issue evaluations have been completed or are in progress. Column 3 indicates concurrence and acceptance with the evaluation by the program in PHMC/TWRS that is responsible for the applicable issue. A "yes" indicates that the evaluation is completed and meets all issue requirements.

The safety screening DQO is listed as "Yes" in Table 4-2 even though the analysis was limited to one composite sample from one riser. However, none of the analyses performed on the grab samples indicate any safety problems.

Table 4-2. Acceptance of Evaluation of Characterization Data and Information for Tank 241-SX-115.

Issue	Evaluation Performed	TWRS/PHMC Program Acceptance
Safety screening DQO	Yes	Yes
Organic complexants MOU[1]	Yes	Yes
Organic solvents DQO[2]	No	n/a

Notes:
[1]The organic complexant safety issue was closed in December 1998 (Owendoff 1998).
[2]The organic solvent safety issue is expected to be closed in 1999.

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APPENDIX A

HISTORICAL TANK INFORMATION

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APPENDIX A

HISTORICAL TANK INFORMATION

Appendix A describes tank 241-SX-115 based on historical information. For this report, historical information includes information about the fill history, waste types, surveillance, or modeling data about the tank. This information is necessary for providing a balanced assessment of sampling and analytical results.

This appendix contains the following information:

- **Section A1.0**: Current tank status, including the current waste levels and the tank stabilization and isolation status
- **Section A2.0**: Information about the tank design
- **Section A3.0**: Process knowledge about the tank, the waste transfer history, and the estimated contents of the tank based on modeling data
- **Section A4.0**: Surveillance data for tank 241-SX-115, including surface-level readings, temperatures, and a description of the waste surface based on photographs
- **Section A5.0**: References for Appendix A.

A1.0 CURRENT TANK STATUS

As of November 30, 1998, tank 241-SX-115 contained an estimated 45.4 kL (12 kgal) of noncomplexed waste (Hanlon 1999). This waste volume was estimated using a manual tape surface-level gauge. Table A1-1 shows the volumes of the waste phases found in the tank.

In 1965, tank 241-SX-115 was declared an assumed leaker, with a leak estimate of 189 kL (50 kgal) (Hanlon 1999). The tank was removed from service in 1965 and interim stabilized in 1978. Intrusion prevention (interim isolation) was completed in December 1982. The tank is passively ventilated and is not on the Watch List (Public Law 101-510).

Table A1-1. Tank Contents Status Summary.[1]

Waste Type	kL (kgal)
Total Waste	45.4 (12)
Supernatant	0 (0)
Sludge	45.4 (12)
Saltcake	0 (0)
Drainable Interstitial Liquid	0 (0)
Drainable Liquid Remaining	0 (0)
Pumpable Liquid Remaining	0 (0)

Note:

[1]Hanlon (1999)

A2.0 TANK DESIGN AND BACKGROUND

The SX Tank Farm was constructed from 1953 to 1954 in the 200 West Area of the Hanford Site. The SX Tank Farm contains fifteen 100-series tanks, each with a capacity of 3,785 kL (1,000 kgal) and a diameter of 22.9 m (75.0 ft). Built according to the third-generation design, the 241-SX Tank Farm was designed for boiling or self-concentrating waste (for a 5- to 10-year boiling period) with a maximum fluid temperature of 121 °C (250 °F) (Leach and Stahl 1997). Because the tanks are designed specifically for boiling waste, airlift circulators were installed to control waste temperatures.

Tank 241-SX-115 entered service in 1958 and is third in a three-tank cascading series. A 7.6-cm (3-in.) cascade line connects this series of tanks. The cascade overflow height is approximately 9.47 m (373 in.) from the tank bottom and 30 cm (1 ft) below the top of the steel liner. These single-shell tanks in the 241-SX Tank Farm are constructed of 61-cm (2-ft.)-thick reinforced concrete with a 0.953-cm (0.375-in.) mild carbon steel liner on the bottom and sides and a 38 cm (1.25 ft)-thick, domed concrete top. They have a dished bottom and an operating depth of 9.24 m (30.3 ft). The tanks are covered with approximately 2.02 m (6.62 ft) of overburden.

Tank 241-SX-115 has 10 risers according to the drawings and engineering change notices. The risers range in diameter from 10 cm (4 in.) to 107 cm (42 in.). Table A2-1 shows numbers, diameters, and descriptions of the risers. A plan view that depicts the riser and nozzle configuration is shown as Figure A2-1. Riser 6 was used for the grab-sampling event in 1998.

A tank cross section showing the approximate waste level along with a schematic of the tank equipment is shown in Figure A2-2.

Table A2-1. Tank 241-SX-115 Risers.[1,2,3]

Number[3]	Diameter		Description and Comments
	Cm	in.	
R1	10	4	Pit drain
R2	10	4	Manual tape surface level gauge, benchmark
R3[5]	10	4	Breather filter
R4	10	4	Isolated thermocouple, grout covered
R5	30	12	Pump, weather covered
R6[4]	30	12	B-222 observation port
R7	30	12	Below grade
R8	30	12	Air circulator lines, concrete covered
R9	61	24	Vapor manifold, below grade
R13	107	42	Below grade
N1	13	5	Spare
N2	10	4	Overflow
N3	10	4	Overflow
N4	9	3.5	Inlet Line V-590, sealed in diversion box 241-SX-151

Notes:

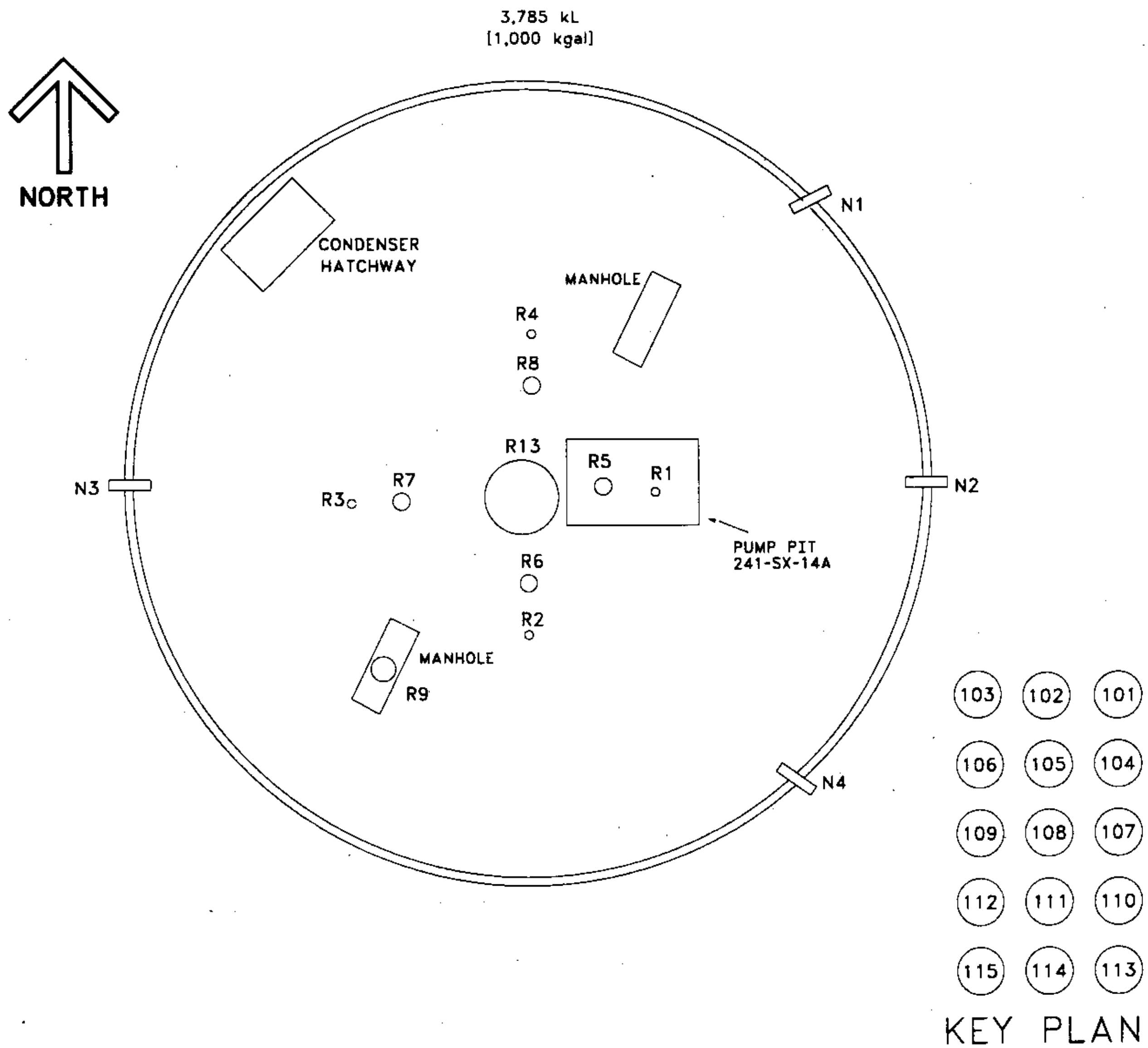
[1]Alstad (1993)

[2]Tran (1993)

[3]Entries beginning with an "R" denote risers, while entries beginning with an "N" denotes inlet/outlets to the tank through the side walls.

[4]Denotes risers tentatively available for sampling.

Figure A2-1. Riser Configuration for Tank 241-SX-115.



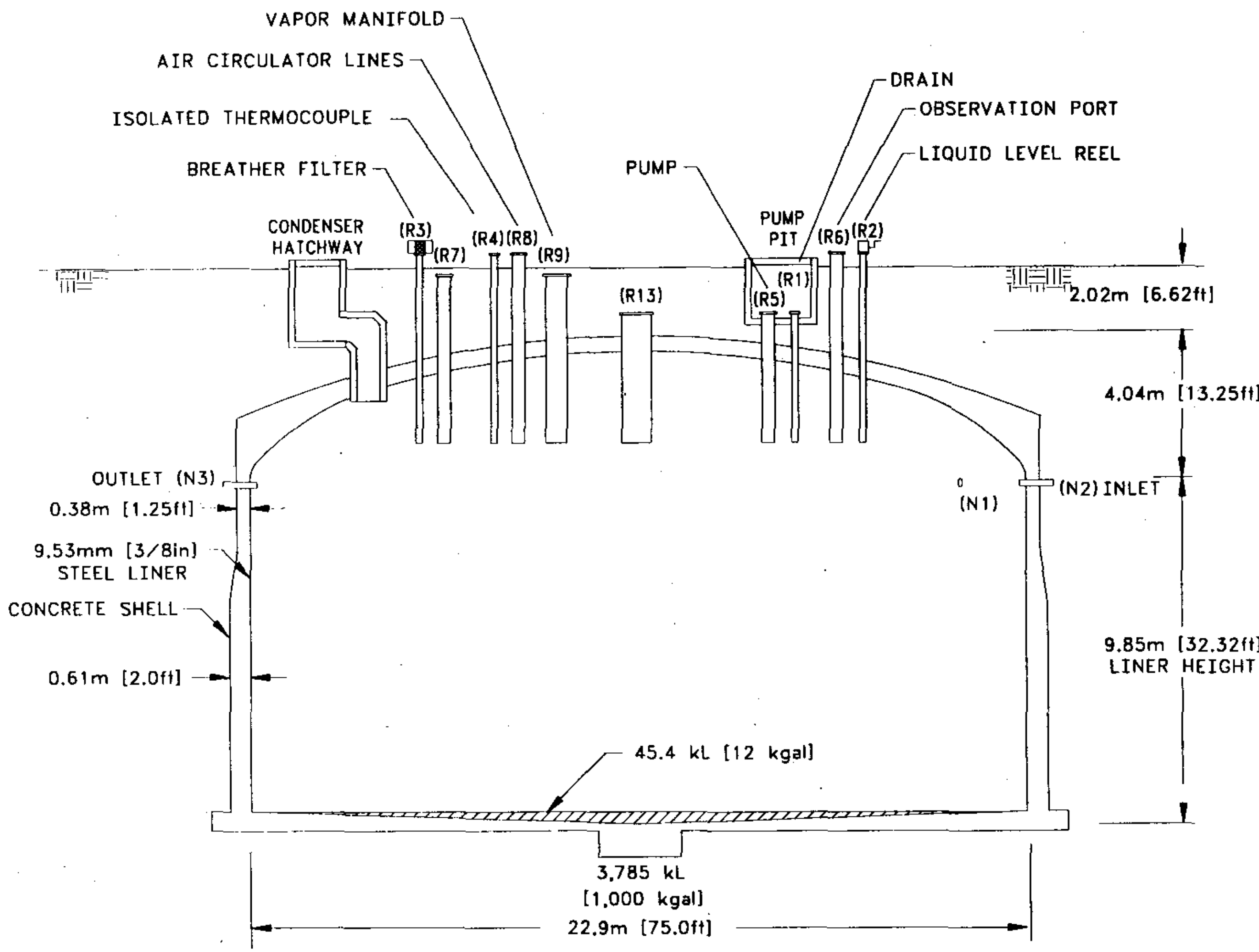


Figure A2-2. Tank 241-SX-115 Cross Section and Schematic.

A3.0 PROCESS KNOWLEDGE

The sections below 1) provide information about the transfer history of tank 241-SX-115, 2) describe the process wastes that made up the transfers, and 3) estimate the current tank contents based on transfer history.

A3.1 WASTE TRANSFER HISTORY

Table A3-1 summarizes the waste transfer history of tank 241-SX-115, which was obtained from Agnew et al. (1997b) and WHC (1992). To preheat the tank in preparation for storage of self-boiling waste, water and REDOX high-level waste (R1) were added to the tank in the third quarter of 1958 (R1 waste was generated from 1952 to 1958 at the REDOX Plant). Sparging of the waste using the airlift circulators occurred during the last quarter of 1958 and the first quarter of 1959, with the condensate from this operation being sent to tank 241-SX-106.

From November 1959 to July 1960, tank 241-SX-115 received self-boiling waste from the REDOX Plant. This waste type is designated R2 (REDOX waste generated from 1959 to 1966) by Agnew et al. (1997b). The waste began self-concentrating soon after receipt, with the condensate from this process being sent to tank 241-SX-106. These condensate transfers to tank 241-SX-106 continued until the fourth quarter of 1961. One receipt of condensate from tank 241-SX-106 was recorded in the fourth quarter of 1960. Several transfers of condensate to an unknown destination are also recorded in Agnew et al. (1997b).

From the third quarter of 1960 through the second quarter of 1965, supernatant waste was transferred both into and out of tank 241-SX-115 from various tanks within the 241-SX Tank Farm. In the second quarter of 1963, waste was transferred from 241-SX-115 to the 202-S Plant for processing. Waste was received from tank 241-S-107 in the fourth quarter of 1964. Water was added several times over the tank's service life. A leak was discovered in March 1965, and nearly all of the remaining supernatant was pumped to tank 241-SX-105. The final transfers, recorded in the fourth quarter of 1965, consisted of the removal of a small amount of waste for evaporation and the subsequent return of the concentrated liquid (REDOX saltcake).

Tank 241-SX-115 was removed from service in 1965 and administratively interim stabilized in 1978. Intrusion prevention (interim isolation) was completed in December 1982. Table A3-1 presents a summary of the major transfers into and out of tank 241-SX-115.

Table A3-1. Tank 241-SX-115 Major Transfers.[1,2]

Transfer Source	Transfer Destination	Waste Type	Time Period	Estimated Waste Volume	
				kL	kgal
Misc.	---	Water	1958 to 1963	1,210	319
REDOX	---	R1	1958 to 1960	549	145
---	241-SX-106	Sparge	1958 to 1959	178	47
REDOX	---	R2	1959 to 1960	3,160	836
---	241-SX-106 Unknown	Condensate	1960 to 1963	3,570	943
241-SX-106 241-SX-109 241-SX-102	---	Supernatant	1960 to 1963	1,980	522
---	241-SX-107 241-SX-108	Supernatant	1963	246	65
---	202-S (REDOX)	Supernatant	1963	246	65
---	241-SX-102	Supernatant	1964	2,170	574
Misc.	---	Water	1964	481	127
---	241-SX-105	Supernatant	1964	787	208
241-S-107	---	Supernatant	1964	265	70
---	Leak		1965	216 (189)	57 (50)[3]
---	241-SX-105	Supernatant	1965	197	52
---	REVAP[4]		1965	7.5	2
REVAP[4]	---	RSltCk	1965	7.5	2

Notes:
RSltCk = REDOX saltcake

[1]Agnew et al. (1997b)

[2]Only major transfers are listed.

[3]Agnew et al. (1997b) lists the leak volume as 216 kL (57 kgal). The tank 241-SX-115 Leak Assessment (WHC 1992) and Hanlon (1999) give a leak volume estimate of 189 kL (50 kgal).

[4]REDOX concentrating process.

A3.2 HISTORICAL ESTIMATION OF TANK CONTENTS

The historical transfer data used for this estimate are from the following sources:

- *Waste Status and Transaction Record Summary: WSTRS, Rev. 4* (Agnew et al. 1997b) is a tank-by-tank quarterly summary spreadsheet of waste transactions.

- *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev.* 4 (Agnew et al. 1997a) contains the HDW list and waste type compositions, the supernatant mixing model (SMM), the tank layer model (TLM), and the HDW model tank inventory estimates.

- The HDW list is comprised of approximately 50 waste types defined by concentration for major analytes/compounds for sludge and supernatant layers.

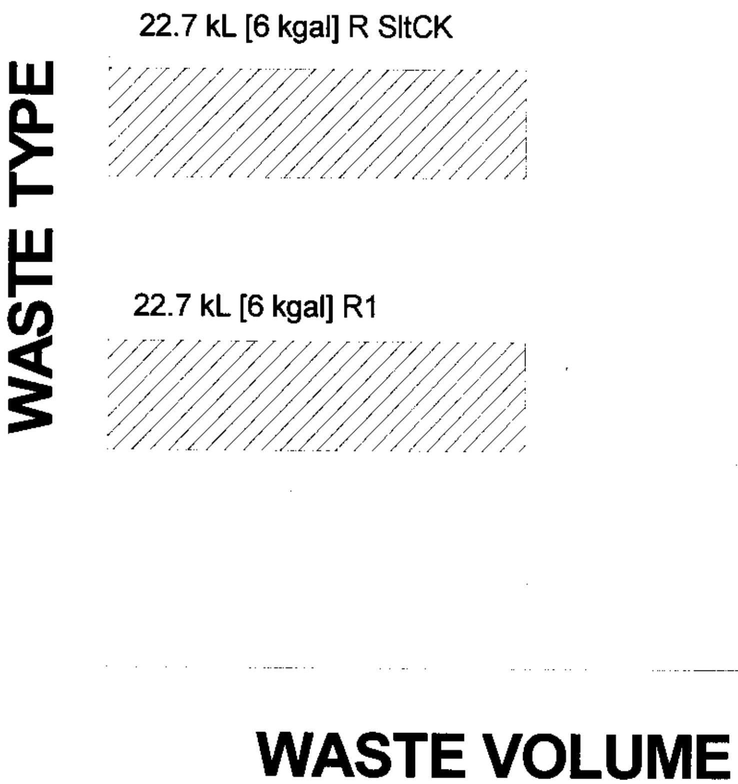
- The TLM defines the solid layers in each tank using waste composition and waste transfer information.

- The SMM is a subroutine within the HDW model that calculates the volume and composition of certain supernatant blends and concentrates.

Using these records, the TLM defines the solid layers in each tank. The SMM uses information from the Waste Status and Transaction Record Summary (WSTRS), the TLM, and the HDW list to describe the supernatants and concentrates in each tank. Together the WSTRS, TLM, SMM, and HDW list determine the inventory estimate for each tank. These model predictions are considered estimates that require further evaluation using analytical data.

Based on Agnew et al. (1997a), tank 241-SX-115 contains 22.7 kL (6 kgal) of R1 waste and 22.7 kL (6 kgal) of REDOX saltcake (RSltCk). Note that this differs with the distribution presented in the best-basis inventory evaluation (see Appendix D). Figure A3-1 is a graphical representation of the estimated waste type and volume for the tank waste, which may not have discernable layers. These predictions have not been validated and should be used with caution. The HDW model predicts that tank 241-SX-115 contains greater than 1 weight percent (wt %) hydroxide, sodium, nitrate, aluminum, nitrite, iron, and chromium. Additionally, carbonate, calcium, chloride, ammonia, sulfate, silicon, nickel, and uranium ore are predicted to be present in quantities between 1 and 0.1 wt %. Strontium-90 and ^{137}Cs are the radionuclides expected to be present in the largest quantities. Table A3-2 shows the historical estimate of the expected waste constituents and their concentrations.

Figure A3-1. Tank Layer Model[1].



Note:

[1]The distribution of volume by waste type shown here differs from that presented in the best-basis inventory section (Appendix D).

Table A3-2. Hanford Defined Waste Model Tank Inventory Estimate.[1, 2, 3] (3 sheets)

Total Inventory Estimate					
Physical Properties				**-95 CI**	**+95 CI**
Total waste	7.88E+04 (kg) (12.0 kgal)				
Heat load	0.223 (kW) (760 Btu/hr)			0.182	0.239
Bulk density[4]	1.73 (g/cc)			1.60	1.98
Water wt%[4]	30.8			16.5	40.8
TOC wt% carbon (wet)[4]	2.59E-03			2.27E-03	3.02E-03
Chemical Constituents	**mole/L**	**ppm**	**kg[5]**	**-95 CI (mole/L)**	**+95 CI (mole/L)**
Na^+	10.8	1.43E+05	1.13E+04	8.26	15.8
Al^{3+}	5.19	8.07E+04	6.36E+03	4.21	6.70
Fe^{3+}	0.515	1.66E+04	1.31E+03	0.506	0.525
Cr^{3+}	0.442	1.32E+04	1.04E+03	0.271	0.940
Bi^{3+}	3.44E-06	0.414	3.26E-02	2.90E-06	4.16E-06
La^{3+}	8.46E-12	6.78E-07	5.34E-08	7.42E-12	1.03E-11
Hg^{2+}	5.40E-07	6.24E-02	4.92E-03	4.78E-07	6.52E-07
Zr	3.43E-07	1.80E-02	1.42E-03	3.15E-07	3.88E-07
Pb^{2+}	8.56E-05	10.2	0.805	4.58E-05	1.26E-04
Ni^{2+}	3.29E-02	1.11E+03	87.7	2.58E-02	3.48E-02
Sr^{2+}	0	0	0	0	0
Mn^{4+}	2.50E-05	0.792	6.24E-02	1.79E-05	3.23E-05
Ca^{2+}	0.148	3.43E+03	270	0.111	0.186
K^+	2.16E-02	487	38.4	1.66E-02	2.46E-02
OH^-	22.1	2.17E+05	1.71E+04	17.6	28.5
NO_3	5.27	1.88E+05	1.48E+04	2.66	11.6
NO_2	1.66	4.41E+04	3.48E+03	1.00	2.01
CO_3^{2-}	0.151	5.22E+03	411	0.114	0.188
PO_4^{3-}	2.22E-04	12.2	0.959	2.06E-04	2.52E-04
SO_4^{2-}	2.54E-02	1.41E+03	111	2.08E-02	2.91E-02
Si	6.90E-02	1.12E+03	88.1	4.52E-02	8.69E-02
F^-	1.77E-04	1.94	0.153	1.51E-04	2.10E-04
Cl^-	9.25E-02	1.89E+03	149	6.17E-02	0.145
$C_6H_5O_7^{3-}$	1.83E-04	20.0	1.57	1.77E-04	2.08E-04
$EDTA^{4-}$	7.13E-06	1.18	9.33E-02	5.02E-06	9.66E-06
$HEDTA^{3-}$	5.92E-06	0.936	7.37E-02	1.90E-06	9.84E-06
Glycolate$^-$	2.58E-04	11.2	0.881	1.40E-04	3.82E-04

Table A3-2. Hanford Defined Waste Model Tank Inventory Estimate.[1, 2, 3] (3 sheets)

Chemical Constituents	mole/L	ppm	kg[5]	-95 CI (mole/L)	+95 CI (mole/L)
Acetate$^-$	2.68E-05	0.913	7.19E-02	2.60E-05	3.05E-05
Oxalate^{2-}	1.11E-11	5.63E-07	4.43E-08	9.82E-12	1.34E-11
DBP	1.62E-04	19.7	1.55	1.52E-04	1.90E-04
Butanol	1.62E-04	6.94	0.547	1.52E-04	1.90E-04
NH_3	0.146	1.43E+03	113	5.08E-02	0.160
$Fe(CN)_6^{4-}$	0	0	0	0	0
Radiological Constituents	**Ci/L**	**µCi/g**	**Ci[3]**	**-95 CI (Ci/L)**	**+95 CI (Ci/L)**
^{3}H	1.26E-04	7.27E-02	5.73	1.46E-05	1.42E-04
^{14}C	6.85E-06	3.95E-03	0.311	1.13E-06	7.61E-06
^{59}Ni	1.08E-05	6.25E-03	0.492	7.43E-06	1.14E-05
^{63}Ni	1.02E-03	0.591	46.5	6.94E-04	1.08E-03
^{60}Co	5.59E-06	3.23E-03	0.254	4.47E-07	6.28E-06
^{79}Se	3.71E-06	2.14E-03	0.169	2.40E-07	7.05E-06
^{90}Sr	0.596	343	2.70E+04	0.462	0.648
^{90}Y	0.596	343	2.71E+04	0.463	0.648
^{93}Zr	1.76E-05	1.01E-02	0.798	1.13E-06	3.16E-05
^{93m}Nb	1.43E-05	8.23E-03	0.648	9.27E-07	2.94E-05
^{99}Tc	5.24E-05	3.02E-02	2.38	4.54E-05	5.95E-05
^{106}Ru	1.19E-09	6.87E-07	5.41E-05	1.25E-12	1.35E-09
^{113m}Cd	2.67E-05	1.54E-02	1.21	3.50E-06	5.32E-05
^{125}Sb	1.90E-05	1.10E-02	0.865	6.56E-07	2.15E-05
^{126}Sn	5.70E-06	3.29E-03	0.259	3.69E-07	1.11E-05
^{129}I	9.96E-08	5.74E-05	4.52E-03	8.61E-08	1.13E-07
^{134}Cs	1.16E-06	6.71E-04	5.29E-02	1.36E-08	1.30E-06
^{137}Cs	0.190	110	8.63E+03	0.169	0.215
^{137m}Ba	0.180	104	8.16E+03	2.65E-02	0.198
^{151}Sm	1.32E-02	7.64	602	8.57E-04	2.56E-02
^{152}Eu	7.93E-06	4.58E-03	0.360	3.50E-06	8.02E-06
^{154}Eu	1.34E-04	7.72E-02	6.08	1.08E-05	1.73E-04
^{155}Eu	3.90E-04	0.225	17.7	1.65E-04	3.94E-04
^{226}Ra	7.75E-10	4.47E-07	3.52E-05	3.09E-10	1.24E-09
^{228}Ra	7.88E-09	4.54E-06	3.58E-04	4.63E-15	8.04E-09
^{227}Ac	3.75E-09	2.16E-06	1.71E-04	1.53E-09	6.46E-09
^{231}Pa	5.53E-09	3.19E-06	2.51E-04	3.59E-10	1.36E-08
^{229}Th	1.90E-10	1.09E-07	8.62E-06	8.84E-13	1.93E-10
^{232}Th	1.06E-10	6.09E-08	4.79E-06	2.95E-16	1.60E-10

Table A3-2. Hanford Defined Waste Model Tank Inventory Estimate.[1,2,3] (3 sheets)

Radiological Constituents (Cont'd)	Ci/L	µCi/g	Ci[3]	-95 CI (Ci/L)	+95 CI (Ci/L)
^{232}U	3.52E-08	2.03E-05	1.60E-03	1.24E-08	6.68E-08
^{233}U	1.35E-07	7.77E-05	6.12E-03	4.76E-08	2.56E-07
^{234}U	6.96E-07	4.01E-04	3.16E-02	3.38E-07	1.09E-06
^{235}U	2.83E-08	1.63E-05	1.28E-03	1.38E-08	4.45E-08
^{236}U	2.73E-08	1.57E-05	1.24E-03	1.30E-08	4.23E-08
^{238}U	6.18E-07	3.57E-04	2.81E-02	3.03E-07	9.73E-07
^{237}Np	2.45E-07	1.41E-04	1.11E-02	2.00E-07	2.79E-07
^{238}Pu	4.49E-06	2.59E-03	0.204	3.55E-06	5.42E-06
^{239}Pu	2.74E-04	0.158	12.4	2.07E-04	3.41E-04
^{240}Pu	4.01E-05	2.31E-02	1.82	3.06E-05	4.96E-05
^{241}Pu	2.59E-04	0.149	11.8	2.03E-04	3.15E-04
^{242}Pu	1.23E-09	7.10E-07	5.59E-05	9.75E-10	1.49E-09
^{241}Am	6.24E-05	3.60E-02	2.83	3.72E-05	1.30E-04
^{243}Am	1.90E-09	1.10E-06	8.63E-05	8.94E-10	2.53E-09
^{242}Cm	8.13E-08	4.69E-05	3.69E-03	7.95E-08	8.19E-08
^{243}Cm	1.86E-09	1.07E-06	8.45E-05	1.82E-09	1.88E-09
^{244}Cm	1.45E-09	8.34E-07	6.57E-05	2.49E-10	1.93E-09
Totals	**M**	**µg/g**	**kg**	**-95 CI (M or g/L)**	**+95 CI (M or g/L)**
Pu	4.58E-03 (g/L)	---	0.208	3.47E-03	5.69E-03
U	7.65E-03	1.05E+03	82.7	3.74E-03	1.21E-02

Notes:
CI = confidence interval
ppm – parts per million

[1]Agnew et al. (1997a)

[2]These predictions have not been validated and should be used with caution.

[3]Unknowns in tank solids inventory are assigned by the TLM.

[4]This is the volume average for density, mass average water wt% and TOC wt% carbon.

[5]Differences exist among the inventories in this column and the inventories calculated from the two sets of concentrations.

A4.0 SURVEILLANCE DATA

Tank 241-SX-115 surveillance consists of surface-level measurements and leak detection well (dry well) monitoring for radioactivity outside the tank. There is no temperature monitoring inside the tank (waste or headspace). Surveillance data provide the basis for determining tank integrity. Solid surface-level measurements indicate physical changes in and consistencies of the solid layers of a tank. Dry wells located around the tank perimeter and laterals under the tank may show increased radioactivity because of leaks.

A4.1 SURFACE-LEVEL READINGS

Quarterly surface level readings are currently taken using a manual tape surface level gauge. Surface level measurements are available from 1981 to the present. The surface level measurement on October 7, 1998 was 15.9 cm (6.25 in.). This surface level is 8.6 cm (3.4 in) lower than the 24.4 cm (9.6 in) expected for the equivalent Hanlon (1999) volume of 45.4 kL (12 kgal). This measured level is lower because of a plummet contacting solids in a hole it created in the waste surface (Swaney 1993). Figure A4-1 is a depiction of the level history through 1995 (Brevick et al. 1997b). A graph of the surface level measurements since January 1996 taken from the Surveillance Analysis Computer System is presented in Figure A4-2. The small change in surface level in late 1996 was an artifact of the measuring method and not an actual change in waste volume. The change was attributed to an uneven waste surface under the manual tape.

Tank 241-SX-115 is categorized as an assumed leaker. Because of the lack of supernatant, no leak detection criterion exists for a decrease in surface level. The surface level increase criterion is 2.5 cm (1 in.) (Welty 1988). Tank 241-SX-115 has six dry wells and three leak detection laterals. Only one of the six dry wells, dry well 41-15-07, had readings above background level. Readings in this dry well decreased from 503 counts per second (c/s) in 1974 to 338 c/s in 1991 (WHC 1992). A second dry well located between tank 241-SX-115 and tank 241-SX-114 had readings slightly above the background level. Radiation readings from laterals 1 and 3 have been erratic and are difficult to interpret. From 1975 through 1988, lateral 3 consistently had the highest readings: 5,000 to 10,000 c/s, compared with only 50 to 90 c/s in lateral 1 and 20 to 30 c/s in lateral . Readings from lateral 2 in 1963 may have indicated a minor leak, as counts were slightly above background. Lateral 2 clearly saw low-level radiation in late 1974 and early 1975, which has since been slowly dissipating (WHC 1992). During this period, the tank was essentially empty with decay heat promoting evaporation of the remaining free water. Radiation readings from the three laterals are available in WHC (1992).

Following discovery of the leak in 1965, ten vertical test wells were drilled around the tank to locate and characterize the contamination. As described in WHC (1992), contamination was found in three zones. Further information regarding the leak from tank 241-SX-115, including an interpretation of the dry well, lateral, and test well data, is presented in WHC (1992).

Additional discussion of the leak and subsequent spread of subsurface contamination is available in *Historical Vadose Zone Contamination of S and SX Tank Farms* (Brevick et al. 1996).

Tank 241-SX-115 does not have a liquid observation well for obtaining information about the quantity of interstitial liquid. However, based on waste surface photographs and observations of the sample material during extrusion and sample handling, no interstitial liquid is anticipated.

A4.2 INTERNAL TANK TEMPERATURES

Tank 241-SX-115 has no temperature monitoring system. Temperature data are not available because the thermocouple tree has been out-of-service since 1991 (Brevick et al. 1997a). There are no plans to restore temperature monitoring.

A4.3 TANK 241-SX-115 PHOTOGRAPHS

The photographs taken on March 31, 1988 should represent the current tank waste appearance. The waste in the photographs appears to have a dry crusted surface with dark brown color. Airlift circulator lines, turbine pump, temperature probe, manhole, and some inlet nozzles are also visible (Brevick et al. 1997b). Recent video surveillance (WHC 1996) revealed a nearly empty tank with a thin crust incompletely covering the tank bottom.

Figure A4-1. Tank 241-SX-115 Level History Through 1995.

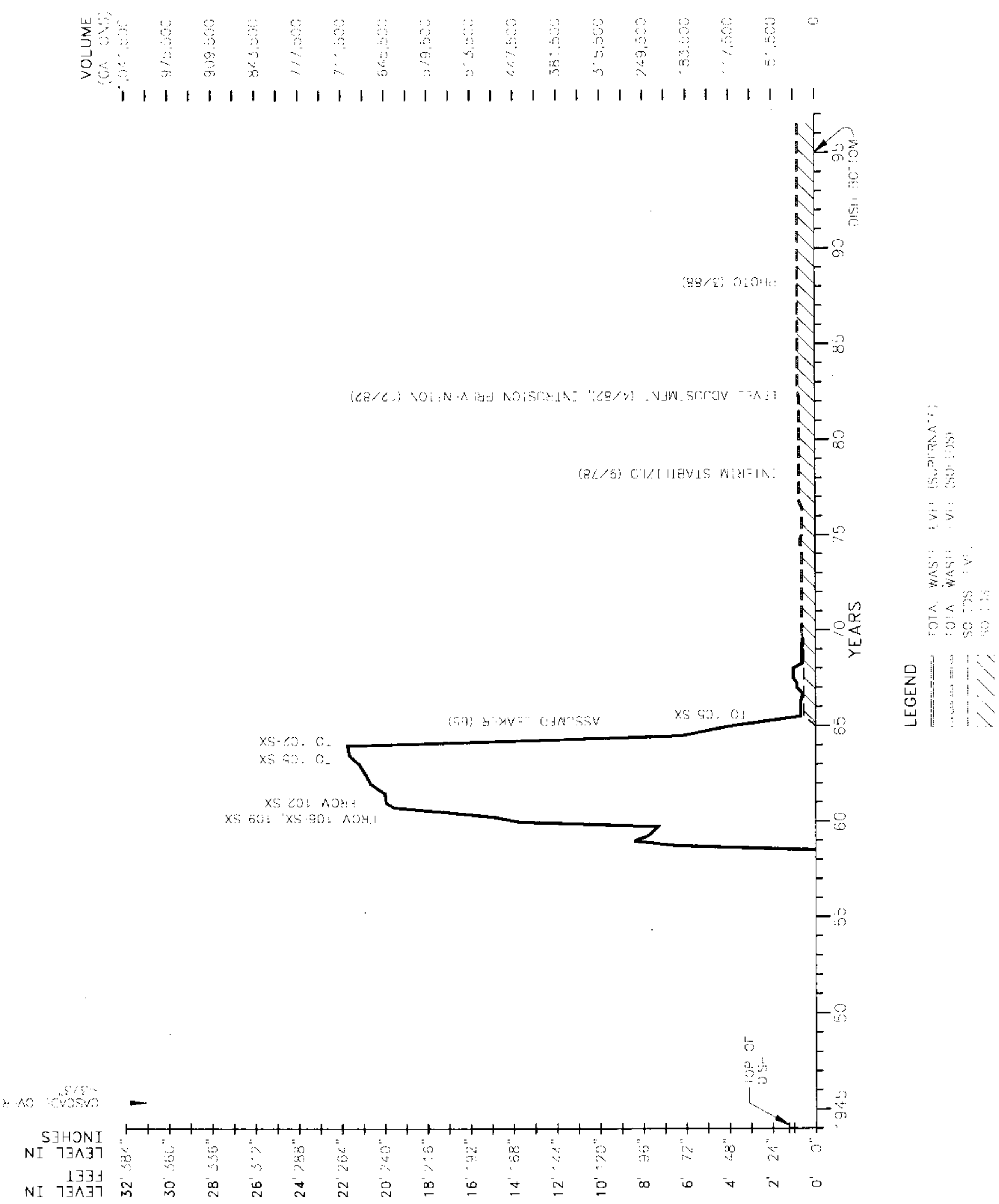


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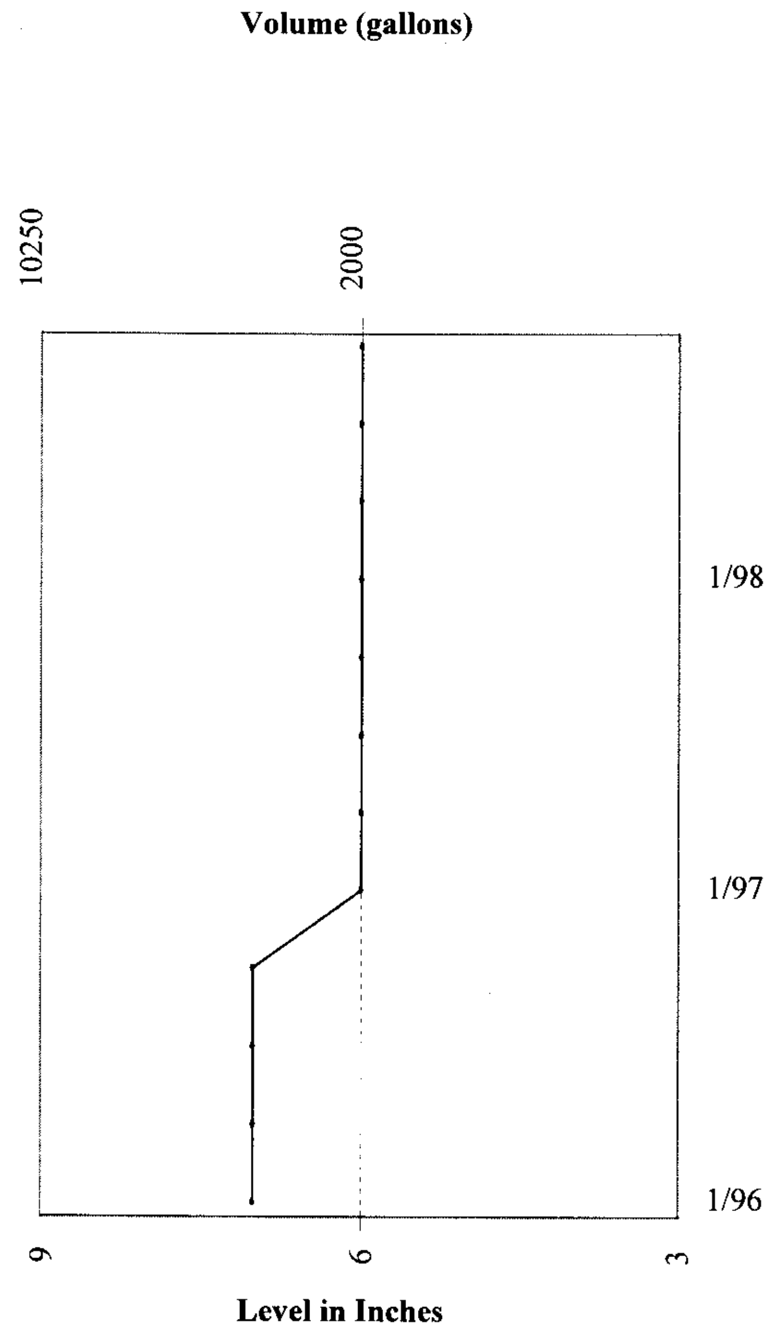
Figure A4-2. Tank 241-SX-115 Level History (Since January 1996).[1]



[1] Surveillance data does not match the waste volume of 45.4 kL (12 kgal) from Hanlon (1999); however the method for measuring surface level has been noted to have anomalies (Swaney 1993).

A5.0 APPENDIX A REFERENCES

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APPENDIX B

SAMPLING OF TANK 241-SX-115

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APPENDIX B

SAMPLING OF TANK 241-SX-115

Appendix B provides sampling and analysis information for each known sampling event for tank 241-SX-115 and assesses sample results. It includes the following.

- **Section B1.0**: Tank Sampling Overview
- **Section B2.0**: Sampling Events
- **Section B3.0**: Assessment of Characterization Results
- **Section B4.0**: References for Appendix B

B1.0 TANK SAMPLING OVERVIEW

This section describes the March 1998 sampling and analysis events and a historical 1975 sludge sampling event for tank 241-SX-115.

The 1998 finger trap grab samples and the 1996 and 1998 headspace flammability measurements were taken to satisfy the requirements of the *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995). The sampling and analyses were performed in accordance with the *Tank 241-SX-115 Grab Sampling and Analysis Plan* (Simpson 1998a) and *Modifications to 241 SX-115 Sample Handling and Analysis* (Simpson 1998b). Modifications from the prescribed safety screening analyses were requested because of radiological controls and limited sample recovery. A prior auger-sampling event in 1995 was not successful. The sludge-sampling event in 1975 is included for historical perspective. No attempt to assess DQOs was made using the historical data. Further discussions of the sampling and analysis procedures can be found in the *Tank Characterization Reference Guide* (DeLorenzo et al. 1994).

B2.0 SAMPLING EVENTS

This section describes sampling events and presents analytical results for tank 241-SX-115. The analytical results from the 1998 finger trap grab samples were used to characterize current tank contents and develop best-basis inventory estimates. Section B2.1 discusses sampling, sample handling, and analysis of the grab samples. Section B2.2 presents tank vapor headspace measurements. The 1975 historical sludge sample results are presented in the Section B2.3. Table B2-1 summarizes the sampling and analytical requirements from the applicable DQOs.

Table B2-1. Integrated Data Quality Objective Requirements for Tank 241-SX-115.[1]

Sampling Event	Applicable DQOs	Sampling Requirements	Analytical Requirements
Grab sampling (solids by finger trap grab)	Safety screening - Energetics - Moisture content - Total alpha - Flammable gas Dukelow et al. (1995)	Samples from minimum of two risers separated radially to the maximum extent possible Combustible gas measurement	Flammability, energetics, moisture, total alpha activity, density
	Organic complexants[2] Schreiber (1997)	Grab samples	
Vapor sampling	Organic solvent[3] Meacham et al. (1977)	Steel canisters, triple sorbent traps, sorbent trap systems	Flammable gas, organic vapors, permanent gases

Notes:

[1]Brown et al. 1997

[2]The organic complexant safety issue was closed in December 1998 (Owendoff 1998).

[3]The organic solvent safety issue is expected to be closed in 1999.

B2.1 1998 GRAB SAMPLING EVENT

Three surface finger trap grab samples were collected from riser 6 of tank 241-SX-115 on March 13, 1998, in accordance with the *Tank 241-SX-115 Grab Sampling and Analysis Plan* (Simpson 1998a). The surface finger trap is a special sampler, designed as a type of "scoop" used to obtain solids samples where the sample depth is minimal, the waste is dry, and/or samples are otherwise difficult to obtain. The three solid samples were combined into one solids composite and analyzed in accordance with *Modifications to 241-SX-115 Sample Handling and Analysis* (Simpson 1998b). No liquids were obtained. A field blank was not received with this sampling event. Combustible gas meter readings in the tank headspace were performed to measure tank headspace flammability before grab sampling.

B2.1.1 Sample Handling

The surface finger trap grab samples were shipped to the 222-S Laboratory for subsampling and analysis. The nature of these samples (dry, friable, and highly radioactive) caused considerable contamination of the exterior of the shipping containers, to the extent that they were bagged and loaded directly into the hotcell. Dose rates were not measured on contact because sample holders were opened inside of the hotcell. Samples were assigned LABCORE numbers and were subjected to visual inspection for color, texture, and solids content. After seventeen days, the glass of the sample jars were beginning to darken, an indication of high beta activity. Visually, the sample appearances were similar. All three samples were combined with all solids used to form a single solids composite sample (78 grams total weight). Before subsampling for analysis, the composite was homogenized using a variable speed handheld blade mixer. Sample descriptions for the grab samples are presented in Table B2-2 (Esch 1998).

Table B2-2. Tank 241-SX-115 Subsampling Scheme and Sample Description.[1]

Sample ID	Date Sampled	Date Received	Weight (g)	Sample Characteristics
15SX-98-1	3/13/98	3/24/98	8.7	The solids were black and very dry. The texture was a mixture of powdery material with larger clumps of solids.
15SX-98-2	3/13/98	3/24/98	65.7	The solids were black and very dry. The texture was a mixture of powdery material with larger clumps of solids
15SX-98-3	3/13/98	3/24/98	3.7	The solids were black and very dry. The texture was a mixture of powdery material with larger clumps of solids.

Note:
[1]Esch (1998)

B2.1.2 Sample Analysis

Safety screening analyses (Dukelow et al. 1995) include: total alpha activity to determine criticality, DSC to ascertain the fuel energy value, and thermogravimetric analysis (TGA) to obtain the total moisture content.

Samples from the solid composite were analyzed based on the modification of the sampling and analysis plan that addressed ALARA and radiological concerns of the tank 241-SX-115 waste sample (Simpson 1998b). The alternate analyses used for safety screening were for comparable analyses. $^{239/240}$Pu and ^{241}Am analyses were determined in place of total alpha activity to achieve a better detection limit in the presence of high beta activity. Total organic carbon analyses (TOC) by the furnace oxidation method was performed on a water-digested aliquot of the sample instead of DSCanalyses. To obtain the total moisture content, gravimetric percent water (% water) analysis was performed in a hotcell to replace thermogravimetric analyses (TGA) in an open hood.

Solids analyses that included $^{239/240}Pu$ and ^{241}Am activity, water content, TOC, and bulk density, were performed by the laboratory on the composite sample. A water digest was performed for furnace oxidation TOC analyses. The gravimetric analysis and bulk density were performed directly on a composite sample in the hot cell. A fusion digest was performed for $^{239/240}Pu$ and ^{241}Am analyses.

Table B2-3 lists the approved analytical procedures used for reported analyses. Table B2-4 summarizes the sample portions, sample numbers, and analyses performed on each sample.

Table B2-3. Analytical Procedures.[1]

Analysis	Method	Procedure Number
^{241}Americium	AEA fusion	LA-549-141 (prep), LA-953-104
$^{239/240}$Plutonium	$^{239/240}$Plutonium fusion	LA-549-141 (prep), LA-953-104
Bulk density	Gravimetry	LO-160-103
Percent water	Percent solids	LA-564-101
Total organic carbon	Furnace oxidation coulometry	LA-504-101 (water digest), LA-344-105

Note:
[1]Esch (1998)

Table B2-4. Sample Analyses Summary [1]

Riser	Sample Identification	Sample Portion	Sample Number	Analyses
6	15SX-98-1	Tank composite	S98T001225	Percent solids
	15SX-98-2		S98T001227	$^{239/240}$Pu, ^{241}Am
	15SX-98-3		S98T001228	Furnace oxidation

Note:
[1]Esch (1998)

B2.1.3 Analytical Results

This section summarizes the sampling and analytical results associated with the March 1998 sampling and analysis of tank 241-SX-115. Table B2-5 indicates which summary tables are associated with the $^{239/240}Pu$ and ^{241}Am activity, percent water, and TOC analytical results. These results are documented in Esch (1998).

Table B2-5. Analytical Tables.

Analysis	Table Number
^{241}Americium	B2-6
$^{239/240}$Plutonium	B2-7
Percent water by percent solids (gravimetric analysis)	B2-8
Total organic carbon by furnace oxidation/coulometry	B2-9

The quality control (QC) parameters assessed in conjunction with tank 241-SX-115 samples were standard recoveries, spike recoveries, duplicate analyses, relative percent difference (RPDs), and blanks. The QC criteria are specified in the sampling and analysis plan (SAP) (Simpson 1998a). Sample and duplicate pairs, in which any QC parameter was outside these limits, are footnoted in the sample mean column of the following data summary tables with an a, b, c, d, or e as follows.

- "a" indicates the standard recovery was below the QC limit.
- "b" indicates the standard recovery was above the QC limit.
- "c" indicates the spike recovery was below the QC limit.
- "d" indicates the spike recovery was above the QC limit.
- "e" indicates the RPD was above the QC limit.

In the analytical tables in this section, the "mean" is the average of the result and duplicate value. All values, including those below the detection level (denoted by "<") were averaged. If both sample and duplicate values were non-detected or if one value was detected while the other was not, the mean is expressed as a non-detected value. If both values were detected, the mean is expressed as a detected value.

B2.1.3.1 Americium-241. Analyses for americium were performed on the composite sample from tank 241-SX-115. The analysis was performed in duplicate from the fusion digestion preparation aliquot. The results were averaged and reported as 14.1 µCi/g. Because there was no customer defined quality control criteria for this analysis, the control limits of the method were used. The standard recovery and the RPD were within these limits.

B2.1.3.2 Plutonium-239/40. Analyses for plutonium were performed on the composite sample from tank 241-SX-115. The analysis was performed in duplicate on an aliquot from the fusion digestion preparation. The results were averaged and reported as 19.9 µCi/g. The standard and spike recoveries were within the required limits.

B2.1.3.3 Gravimetric Analysis. Gravimetric analyses were performed for the tank 241-SX-115 composite. The gravimetric results provide an estimate of the moisture content of the samples. The standard recovery and the RPD for this analysis met the quality control criteria requested for the TGA determination. The average result was 10.1 % water.

B2.1.3.4 Bulk Density. The bulk density determination was performed, but because of the nature of the sample the volume could not be measured accurately. The sample consisted of dry, powdery solids with chunks of larger material. This type of sample exhibits a higher volume per unit mass, resulting in a bulk density that is biased low. Therefore, no bulk density volume value was reported

B2.1.3.5 Total Organic Carbon. Total organic carbon was determined using furnace oxidation/coulometry on the water digested aliquot. No organic carbon was detected in the sample at the lower detection limit of 1,070 μgC/g. The standard and spike recoveries were within the required limits.

B2.1.4 1998 Grab Sample Data Tables

Table B2-6. Tank 241-SX-115 Analytical Results: Americium-241 (AEA).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Average
Solids: fusion			**μCi/g**	**μCi/g**	**μCi/g**
S98T001227	Tank composite	Solid composite	14.2	13.9	14.1

Table B2-7. Tank 241-SX-115 Analytical Results: Plutonium-239/240

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Average
Solids: fusion			**μCi/g**	**μCi/g**	**μCi/g**
S98T001227	Tank composite	Solid composite	20.2	19.5	19.9

Table B2-8. Tank 241-SX-115 Analytical Results: Percent Water (Percent Solids)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Average
Solids			**%**	**%**	**%**
S98T001225	Tank composite	Solid composite	11.3	8.9	10.1

Table B2-9. Tank 241-SX-115 Analytical Results: Total Organic Carbon (Furnace Oxidation)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Average
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
S98T001228	Tank composite	Solid composite	<1,070	<1,170	<1,120

B2.2 VAPOR PHASE MEASUREMENT

The vapor phase measurements were taken 20 ft below riser 6 in the dome space of the tank and results were obtained in the field (that is, no gas sample was sent to the laboratory for analysis). The results of the vapor phase measurements are provided in Table B2-10.

Table B2-10. Results of Headspace Measurements of Tank 241-SX-115.

Measurement	Result March 8, 1996[1]	Result March 13, 1998
TOC	< 0.5 ppm	0.ppm
LEL	< 1 % of LEL	0 % of LEL
Oxygen	21.1 %	20.9 %
Ammonia	< 5 ppm	0 ppm

Note:

LEL = lower explosive limit

[1]Pennington 1996.

B2.3 DESCRIPTION OF HISTORICAL SAMPLING EVENT

Sampling data for tank 241-SX-115 was presented in a letter June 13, (Raymond and Shdo 1966). No information was available on sample handling and sample analysis and the data is not presented in this section.

Sampling data for tank 241-SX-115 have been obtained for one sample taken on March 10, 1975 and reported on April 22, 1975 (Horton 1975). The data are presented in Section B2.4. Pre-1989 analytical data have not been validated and should be used with caution. No information was available regarding sample handling for this event. The sludge sample was received on March 10, 1975. The sludge sample from tank 241-SX-115 was dark brown and quite dry. Sludge analyses were made by fusing the sludge with KOH, dissolving it in concentrated hydrochloric acid, and diluting with water.

B2.4 HISTORICAL DATA TABLES

Table B2-11. March 10, 1975 Sludge Sample Results.[1]

Component	Value
Al	3.15 *M*
Fe	1.64 *M*
Mg	<0.2 *M*
Mn	0.40 *M*
Ca	0.34 *M*
NO_2	0.08 *M*
PO_4	<0.19 *M*
Si	0.6 *M*
Na	1.92 *M*
Pu	0.196 grams/L
$^{89/90}Sr$	4.79E+07 µCi/L
^{137}Cs	70,500 µCi/L
^{134}Cs	41,100 µCi/L
^{60}Co	31,900 µCi/L
^{125}Sb	4.22E+5 µCi/L
^{154}Eu	92,500 µCi/L
As received density	0.55
Particle density	2.48
% H_2O	4.4

Note:

[1]These data have not been validated and should be used with caution. No units were given for density, particle density and percent H_2O.

B3.0 ASSESSMENT OF CHARACTERIZATION RESULTS

This section discusses the overall quality and consistency of the current sampling results for tank 241-SX-115 and provides the results of an analytical-based inventory calculation.

This section also evaluates sampling and analysis factors that may impact data interpretation. These factors are used to assess overall data quality and consistency and to identify limitations in data use.

B3.1 FIELD OBSERVATIONS

The most notable observations regarding the grab samples obtained from tank 241-SX-115 during the 1998 sampling event were the low sample recovery, and the extreme difficulty of radioactive control of the samples during sampling and analysis. These problems resulted in modifications to the sampling and analysis plan, to composite the three grab samples and perform limited analyses. The 1998 analytical data set has one primary and duplicate per four analyses. Low sample recovery and minimal sample analyes makes it difficult to draw direct conclusions about the relationships between the analytical results and the bulk tank contents.

An auger-sampling attempt in 1995 was unsuccessful. In the 1998 sampling event, the grab samples were taken only from one riser, using a special sampling device (finger trap grab sampler) to scoop the material from the waste surface. Two of the three grab samples trapped less than 9 grams of the sample material. The waste samples were dry and friable with high radioactivity.

B3.2 QUALITY CONTROL ASSESSMENT

The usual QC assessment includes an evaluation of the appropriate standard recoveries, spike recoveries, duplicate analyses, and blanks that are performed in conjunction with the chemical analyses. All pertinent QC tests were conducted on 1998 finger grab samples, allowing a full assessment regarding the accuracy and precision of the data. The SAP (Simpson 1998a) established specific criteria for all analytes. Sample and duplicate pairs with one or more QC results outside the specified criteria were identified by footnotes in the data summary tables.

The standard and spike recovery results provide an estimate of analysis accuracy. If a standard or spike recovery is above or below the given criterion, the analytical results may be biased high or low, respectively. The precision is estimated by the RPD, which is defined as the absolute value of the difference between the primary and duplicate samples, divided by their mean, times 100. Reruns were deemed unnecessary as the sample results were far below the action limit. No sample exceeded the criterion for preparation blanks; thus, contamination was not a problem.

In summary, QC results were within the boundaries specified in the SAPs. The discrepancies mentioned here and footnoted in the data summary tables should not impact data validity or use.

B3.3 DATA CONSISTENCY CHECKS

The ability to assess the overall consistency or trends of the data for the grab sample is limited. Because of the limited quantity of sample material recovered and because very few sample assays were performed, inductively coupled plasma (ICP) and ion chromatography (IC) analysis were not conducted. Mass and charge balance calculations were not possible given the limited data. Comparisons of results from different analytical methods were not possible given limited analyses.

B3.4 MEAN CONCENTRATIONS AND CONFIDENCE INTERVALS

An analysis of variance (ANOVA) model was fit to the core segment data. Mean values, and 95 percent confidence intervals on the mean, were determined from the ANOVA. The model is:

$$Y_I = \mu + A_i,$$

$$i = 1,2,\ldots,a;$$

where

Y_I = concentration from the i^{th} analytical result

μ = the mean

A_i = the analytical error

a = the number of analytical results

The restricted maximum likelihood method (REML) was used to estimate the mean concentration and standard deviation of the mean for all analytes that had 50 percent or more of their reported values greater than the detection limit. The mean value and standard deviation of the mean were used to calculate the 95 percent confidence intervals. Table B3-1 gives the mean, degrees of freedom, and confidence interval for each constituent.

Some analytes had results that were below the detection limit. In these cases the value of the detection limit was used for non-detected results. For analytes with a majority of results below the detection limit, a simple average is all that is reported.

The lower and upper limits, LL(95%) and UL(95%), of a two-sided 95 percent confidence interval on the mean were calculated using the following equation:

$$LL(95\%) = \hat{\mu} - t_{(df,\ 0.025)} \times \hat{\sigma}(\hat{\mu}),$$
$$UL(95\%) = \hat{\mu} + t_{(df,\ 0.025)} \times \hat{\sigma}(\hat{\mu}).$$

In this equation, $\hat{\mu}$ is the REML estimate of the mean concentration, $\hat{\sigma}(\hat{\mu})$ is the REML estimate of the standard deviation of the mean, and $t_{(df,\ 0.025)}$ is the quantile from Student's t distribution with *df* degrees of freedom. The degrees of freedom equals the number of observations minus one. In cases where the lower limit of the confidence interval was negative, it is reported as zero.

Table B3-1. Tank 241-SX-115 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Solid Tank Composite. Data (Reference Date - December 16, 1998)

Analyte	Method	Mean	*df*	LL	UL	Units
^{241}Americium	AEA:F	14.1	1	12.1	16.0	µCi/g
Percent water	Percent solids	10.1	1	0	25.3	%
$^{239/240}$Plutonium	Pu239/240:F	19.9	1	15.4	24.3	µCi/g
Total organic carbon*	Furnace oxidation:W	<1,120	N/a	n/a	n/a	µg/g

Note:

* a "less than" value was used in the calculation

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APPENDIX C

STATISTICAL ANALYSIS FOR ISSUE RESOLUTION

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APPENDIX C

STATISTICAL ANALYSIS FOR ISSUE RESOLUTION

Appendix C documents the results of the statistical and numerical manipulations required by the DQOs applicable to tank 241-SX-115. The analyses required for tank 241-SX-115 are reported as follows:

- **Section C1.0**: Statistical analysis and numerical manipulations supporting the safety screening DQO (Dukelow et al. 1995).
- **Section C2.0**: Appendix C references.

C1.0 STATISTICS FOR THE SAFETY SCREENING DATA QUALITY OBJECTIVE

The safety screening DQO (Dukelow et al. 1995) defines decision limits in terms of one-sided 95 percent confidence intervals. The safety screening DQO limits are 35.5 μCi/g for total alpha activity and 480 J/g for DSC. As directed by Simpson (1998), total alpha activity analyses were replaced by a $^{239/240}Pu$ and ^{241}Am analyses. Because the safety screening criticality decision threshold of 35.5 μCi/g is actually based on a limit of 1 g/L of Pu, the $^{239/240}Pu$ results were used for comparison to the 35.5-μCi/g limit. The confidence interval calculated for the $^{239/240}Pu$ mean value from the solid composite sample is presented in Table C1-1. Simpson (1998) also replaced the DSC analysis with a TOC analysis by furnace oxidation. However, because all of the TOC analytical results were below detection limits, no confidence intervals were determined.
The UL of a one-sided 95 percent confidence interval on the mean is

$$\hat{\mu} + t_{(df,0.05)}\, \hat{\sigma}_{\mu}$$

In this equation, $\hat{\mu}$ is the arithmetic mean of the data, $\hat{\sigma}_{\mu}$ is the estimate of the standard deviation of the mean, and $t_{(df,0.05)}$ is the quantile from Student's t distribution with *df* degrees of freedom. The degrees of freedom equal the number of samples minus one.

A confidence interval can be used to make the following statement. If the UL is less than 35.5 μCi/g, then one would reject the null hypothesis that the $^{239/240}Pu$ concentration is greater than or equal to 35.5 μCi/g at the 0.05 level of significance. The UL from the solid composite sample was 22.1 μCi/g. This value is approximately 40 percent below the limit of 35.5 μCi/g.

Table C1-1. 95 Percent Confidence Interval Upper Limits for Plutonium-239/240.

Lab Sample ID	Description	Result	Duplicate	μ	*df*	UL	Units
S98T001227	Solid composite	20.2	19.5	19.9	1	22.1	μCi/g

As mentioned previously, all of the TOC results were below detection levels (Esch 1998). Consequently, no confidence intervals were calculated. The higher of the two non-detected values was < 1,170 μg C/g, well below the 45,000-μg C/g threshold.

C2.0 APPENDIX C REFERENCES

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-SX-115

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-SX-115

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of available information for single-shell tank 241-SX-115 was performed and a best-basis inventory was established. This work, detailed in the following sections, follows the methodology that was established by the standard inventory task.

The following sections establish a best-basis inventory estimate for chemical and radionuclide components in tank 241-SX-115. A complete list of data sources and inventory evaluations is provided at the end of this section.

D1.0 CHEMICAL INFORMATION SOURCES

The waste in tank 241-SX-115 was most recently sampled in March 1998 using the finger trap grab sampling method. Three samples were combined to form a single composite, and a limited set of analyses was performed. Only results for TOC, $^{239/240}$Pu, ^{241}Am, and moisture content were obtained. These results are reported in Esch (1998). Because of the limited amount of data, a complete sample-based inventory could not be generated. A small amount of data is available from the analysis of a 1975 sludge sample (Horton 1975). At the time of the 1975 sampling, Agnew et al. (1997b) indicates that tank 241-SX-115 contained 22.7 kL (6 kgal). The quality of this volume estimate is unknown. Substantial uncertainty is known to exist in the surveillance data from the mid-1970s for the SX Tank Farm (Anderson 1990). Although no transfers have been made to the tank since 1975, the volume is currently recognized to be 45.4 kL (12 kgal) (Agnew et al. 1997b; Hanlon 1999). The current volume was used when converting the 1975 concentration data to inventories. Tank 241-SX-115 has a dished bottom. Because the volume of the dish is 70.0 kL (18.5 kgal), the total waste volume remaining in the tank is completely contained within the dish.

A previous best-basis inventory was generated for tank 241-SX-115 based on sampling data from other tanks that contain REDOX HLW, designated R waste (R waste is further differentiated by Agnew et al. [1997a] according to generation dates; waste generated from 1952 to 1958 is designated R1, while R waste generated from 1959 to 1966 is designated R2).

Inventories were derived by averaging data from tanks 241-S-101, 241-S-104, and 241-S-107. Only certain data from these tanks were used in the calculation, specifically:

- segments 7 upper through 8 lower for tank 241-S-101 (Kruger et al. 1996);
- the total sludge concentration for tank 241-S-104 (DiCenso et al. 1994); and
- the statistically-determined median R1 sludge concentrations for tank 241-S-107 contained in the attachment to Simpson et al. (1996).

The HDWmodel (Agnew et al. 1997a) provides tank content estimates in terms of component concentrations and inventories.

Tank 241-SX-115 is classified an assumed leaker (Hanlon 1999). However, the quantity of material lost to the soil column is currently unknown. No attempt has been made in this assessment to correct for materials lost to the soil column.

D2.0 COMPARISON OF COMPONENT INVENTORY VALUES

Hanlon (1999) states that tank 241-SX-115 contains 45.4 kL (12 kgal) of solids and no drainable interstitial liquid or pumpable liquid. Agnew et al. (1997a) concurs with the Hanlon estimate. According to the HDW model, the solid waste in tank 241-SX-115 contains 30.8 wt% water and has a density of 1.73 g/mL. As described more fully later, Agnew et al. (1997a) hypothesize that the solids in tank 241-SX-115 derive from both REDOX HLW and saltcake produced from concentrated REDOX process supernatant liquid added to the tank. An independent analysis of historical waste transaction data, conducted in connection with the preparation of this section, indicates that all the solid waste in tank 241-SX-115 derives only from REDOX process HLW. As explained in detail later, the completeness and quality of the historical waste transaction data are insufficient to allow an absolute determination of the origin of the solid wastes now in tank 241-SX-115.

The previous best-basis inventory and the HDW model inventory predictions for selected analytes in tank 241-SX-115 are listed in Table D2-1. (The chemical species are reported without charge designation per the best-basis inventory convention.)

Table D2-1. Estimated Analyte Inventories for Tank 241-SX-115. (2 sheets)

Analyte	Previous Best-Basis (kg)	HDW Model[1] (kg)
Nonradioactive Constituents		
Al	7,890	6,360
Bi	3.33	0.0326
Ca	21.1	270
Cl	187	149
CO_3	326	411
Cr	151	1,040
F	9.46	0.153
Fe	127	1,310
Hg	0	0.00492
K	34.0	38.4
La	0	5.34E-08
Mn	105	0.0624
Na	7,710	11,300
Ni	9.3	87.7
NO_2	2,400	3,480
NO_3	9,660	14,800
OH	17,200	17,100
Pb	2.62	0.805
PO_4	136	0.959
Si	98.5	88.1
SO_4	117	111
Sr	33.0	0
TOC	136	2.04
U_{TOTAL}	606	82.7
Zr	5.27	0.00142
^{60}Co	(used HDW value)	0.254
^{90}Sr	22,700	27,000
^{125}Sb	(used HDW value)	0.865
^{134}Cs	(used HDW value)	0.0529
^{137}Cs	6,110	8,630

Table D2-1. Estimated Analyte Inventories for Tank 241-SX-115. (2 sheets)

Analyte	Previous Best-Basis (kg)	HDW Model[1] (kg)
^{154}Eu	(used HDW value)	6.08
^{239}Pu	(used HDW value)	12.4

Notes:

[1]Agnew et al. (1997a)

[2]Decayed to January 1, 1994.

D3.0 COMPONENT INVENTORY EVALUATION

The following evaluation of tank contents is performed to identify potential errors and/or missing information that would have an effect upon the various inventories, and to determine the most appropriate inventory for describing the tank waste components.

There is some uncertainty regarding the waste volume in tank 241-SX-115. Both Hanlon (1999) and Agnew et al. (1997b) report a waste volume of 45.4 kL (12 kgal), which is approximately equivalent to 24.4 cm (9.6 in.). However, the surface level measurement on October 17, 1998, yielded a result of 15.9 cm (6.25 in.), equivalent to a waste volume of 10.2 kL (2.7 kgal) (Swaney 1993). Some of this difference can be attributed to an uneven waste surface. Swaney (1993) indicates that a depression exists in the waste surface at the point at which it is contacted by the measuring device (plummet), biasing the measurement low. As discussed in Section A4.3, recent video surveillance does indicate that the waste volume may be less than 45.4 kL (12 kgal). However, in order to provide the most conservative estimates, 45.4 kL (12 kgal) is used as the volume for deriving the best-basis inventories.

D3.1 CONTRIBUTING WASTE TYPES

Tank 241-SX-115 is the third (million-gallon) tank in a cascade that includes tanks 241-SX-113 and 241-SX-114. Tank 241-SX-115 was constructed in the early 1950's and was designed to be a self-boiling tank with the condensate directed back to the tank. Tank 241-SX-115 was connected to an exhauster.

High-level REDOX process waste was received by tank 241-SX-115 from 1958 through 1960. Agnew et al. (1997b) indicates that the R waste received in 1958 was R1, while the R waste received in 1959 and 1960 was R2. In 1965, tank 241-SX-115 also received a one-time addition of concentrated REDOX process HLW supernatant liquid. Only these high-level REDOX process waste additions contributed to the solid waste (45.4 kL [12 kgal]) now stored in tank 241-SX-115 (Agnew et al. 1997a). Beyond such waste additions, there were some liquid transfers into and out of tank 241-SX-115 including water, condensate from self-boiling tanks including tank 241-SX-115, and supernatant liquid from other SX and S Tank Farm tanks. None of these transfers of liquid waste are expected to have contributed to the solids currently in the tank.

Table D3-1 provides a summary of the transactions that may have contributed to the type of wastes now in tank 241-SX-115 (Agnew et al. 1997b). Based on the volume percent solids values given in Agnew et al. (1997a) for each of these waste streams, the projected amount of solids that may have been deposited in the tank is also shown in the table.

Table D3-1. Summary of Contributing Waste Types for Tank 241-SX-115.[1]

Historical Waste Transaction	Waste type		
	R1	**R2**	**RSltCk**
Volume of waste added, kL (kgal)			
1958	549 (145)	---	---
1959	---	855 (226)	---
1960	---	2,309 (610)	---
1965	---	---	7.6 (2)
Volume of projected solids from waste streams added, kL (kgal)			
1958	24.7 (6.53)[2]	---	---
1959	---	16.2 (4.29)[3]	---
1960	---	43.9 (11.6)[3]	---
1965	---	---	1.06 (0.28)[4,5]

Notes:

RSltCk = REDOX saltcake

[1]Agnew et al. (1997b)

[2]Based on the Agnew et al. (1997a) estimate of 4.5 volume percent solids for R1 waste.

[3]Based on the Agnew et al. (1997a) estimate of 1.9 volume percent solids for R2 waste.

[4]Based on the Agnew et al. (1997a) estimate of 13.82 volume percent solids for RSltCk.

[5]Note that RSltCk was also created through self-concentration of the waste.

The source of the solids currently in the tank and the manner in which they were deposited is open to interpretation. Agnew et al. (1997a) partitions the amount of solid waste (based on the measured volume of 45.4 kL [12 kgal]) into two types:

- 22.7 kL (6 kgal) solids of R1 waste
- 22.7 kL (6 kgal) of REDOX process saltcake (RSltCk).

To derive this estimate, Agnew et al. (1997a) first assumed that the present solids volume quoted by Hanlon (1999), 45.4 kL (12 kgal), was correct. Then, 22.7 kL (6 kgal) of the overall total was attributed to RSltCk because of an unexplained gain of that amount in the measured solids volume; this gain presumably occurred over the years 1966 to 1993, even though no waste was added to the tank and virtually all of the liquid had been removed. Records of both the solid and liquid volumes from 1966 to 1993 are erratic, increasing and decreasing seemingly arbitrarily. Agnew et al. (1997a) ascribe the difference between the measured total solids volume and the volume of saltcake to REDOX process sludge, yielding 22.7 kL (6 kgal).

An alternative way of accounting for the solid waste now in tank 241-SX-115 involves the following analysis and evaluation:

- 24.7 kL (6.53 kgal) of solids (4.5 volume percent of 549 kL [145 kgal]) of R1 waste produced in 1958 (Agnew et al. 1997a).
- 16.2 kL (4.29 kgal) of solids (1.9 volume percent of 855 kL [226 kgal]) of R2 waste produced in 1959 (Agnew et al. 1997a).
- 43.9 kL (11.6 kgal) of solids (1.9 volume percent of 2,309 kL [610 kgal]) of R2 waste produced in 1960 (Agnew et al. 1997a).
- Negligible volume of concentrated REDOX process supernatant liquid added in 1965 (Agnew et al. 1997a).
- Unexplained discrepancy of 39.44 kL (10.42 kgal) of waste solids in the period 1960 through 1965.

The second alternative, just as the first used by Agnew et al. (1997a), accounts for the 45.4 kL (12 kgal) of solid waste remaining in tank 241-SX-115. However, because of the tank process history, it is probably inappropriate to consider that distinct layers of solids exist in tank 241-SX-115. Although there was a chronological order in the receipt of the waste types, the waste in the tank self-boiled for at least two years (Agnew et al. 1997b), which would have caused a substantial amount of mixing of the R1 and R2 solids. Also, precipitates would have dropped out of solution during the boiling period, creating what Agnew et al. (1997a) considers

RSltCk. Consequently, the waste is assumed to be a complex mixture of R1, R2, and RSltCk. Therefore, this evaluation designates the tank 241-SX-115 waste as R waste.

The decrease in the amount of solids may have occurred because of the many receipts of water and supernatant from other tanks from 1960 to 1965, which could have dissolved or resuspended some of the waste solids. Also, because the tank leak occurred during the same period, some of the soluble solids may have been lost with the liquid that escaped from the tank. Another possible explanation for the discrepancy in solids volume is a high bias in the estimated volume percent solids value for each waste stream from Agnew et al. (1997a). Fluctuations in the reported solids volume after waste transfers ceased are probably artifacts of the surface level measurement method and an uneven waste surface.

Expected Solids in Waste

Anderson (1990): R
Agnew et al. (1997a): R1, RSltCk
This Evaluation: R

Predicted Current Inventory

Agnew et al. (1997a)

Waste Type	Total Waste Volume: 45.4 kL (12 kgal)
R1	22.7 kL (6 kgal)
RSltCk	22.7 kL (6 kgal)

Hanlon (1999)

Waste Type	Total Waste Volume: 45.4 kL (12 kgal)
Sludge	

This Evaluation

Waste Type	Total Waste Volume: 45.4 kL (12 kgal)
R	45.4 kL (12 kgal)

D3.2 EVALUATION OF TECHNICAL FLOWSHEET INFORMATION

Table D3-2 (reproduced from information in Kupfer et al. 1998) lists compositions for REDOX process HLW produced according to Flowsheets No. 5 and 6. Also listed are the R1 and R2 compositions from the HDW Model (Agnew et al. 1997a). The R1 waste received in 1958 was produced under the conditions of REDOX process Flowsheet No. 5, while the R2 waste received in 1959 and 1960 was produced under the conditions of REDOX process Flowsheet No. 6.

Table D3-2. Composition of REDOX Process High-Level Waste.

	REDOX Process HLW Composition[1] (*M*)		**HDW Model Predictions[2] (*M*)**	
Analyte	**Flow sheet No. 5**	**Flow sheet No. 6**	**R1 Waste Type**	**R2 Waste Type**
Al	1.29	0.95	1.13	1.13
Bi	0	4.9 E-05	0	0
Cr	0.17	0.13	0.113	0.113
Fe	0.0074	0.0075	0.0475	0.053
I	0	4.3 E-05	0	0
K	0.0034[3]	0.0034[3]	0.0205	0.02
Mn	0.0034[3]	0.0034[3]	0	0
Na	7.1	7.3	5.50	5.46
NO_3	4.3	3.8	2.98	2.68
Oxalate	0.0077	0.0080	0	0
SO_4	0.023	0.022	0.019	0.03
U	0.0037	6.6 E-04	0.00279	0.00211
Issue Date	8/55	10/60	---	---

Notes:

[1]Adapted from tables in Kupfer et al. (1998)

[2]Agnew et al. (1997a)

[3]Not shown on published flow sheet, but $KMnO_4$ usage in REDOX plant is known to have continued until the fall of 1959.

The composition listed in Table D3-2 for REDOX process flow sheet No. 6 specifies that the waste contained 0.0034 M $KMnO_4$. The published version of flow sheet No. 6 does not include any mention of $KMnO_4$. Information presented in Kupfer et al. (1998) indicates that $KMnO_4$ was used in the REDOX process through most of 1959. Also, note that REDOX process HLW generated under the conditions of either flow sheets No. 5 or 6 contained almost identical concentrations of insoluble metals, for example, Fe, Mn, Bi, and U.

D3.3 PREDICTED WASTE INVENTORY

D3.3.1 Application of Analytical Data for Wastes in Tank 241-SX-108

Because so few analytes were measured on the 1998 finger grab samples, a full set of inventory estimates could not be derived based on analytical data from tank 241-SX-115. A 1975 sample also did not provide a full inventory. In order to derive inventory estimates based on analytical data, information on other tanks containing REDOX HLW was examined. The original best-basis for tank 241-SX-115 was based on an average of analytical means from specific segments of waste from tanks 241-S-101, 241-S-104, and 241-S-107. Additional tanks that contain the R1 and R2 waste types have been sampled (tanks 241-S-111, 241-SX-101, and 241-SX-108). The few analytical results from tank 241-SX-115 were compared with the data from those tanks and the original best-basis. Based on this comparison, the data from tank 241-SX-108 appears most appropriate to represent the waste in tank 241-SX-115.

The selection of tank 241-SX-108 to represent tank 241-SX-115 is further supported by their similar process histories. Both received R1 and R2 waste that self-boiled while in the tank. According to Agnew et al. (1997a), tank 241-SX-108 is predicted to contain a 261-kL (69-kgal) layer of R1 waste underneath a 68-kL (18-kgal) layer of R2 waste.

Upon review of the data from the analysis of the two September 1995 auger samples for tank 241-SX-108, substantial concentration differences among the augers are apparent. The differences are primarily present between augers rather than within the augers (horizontal variation as opposed to vertical variation). The total alpha data from auger sample 95-AUG-043 were two and a half times greater than the data from auger 95-AUG-042, and were closest to the values obtained from tank 241-SX-115. Therefore, only data from auger 95-AUG-043 of tank 241-SX-108 have been used in this best-basis evaluation.

Table D3-3 lists concentration data from analysis of auger 95-AUG-043 from tank 241-SX-108. The average concentration for this auger sample is believed to best represent the composition of the REDOX process HLW sludge in tank 241-SX-115. An inventory based on the tank 241-SX-108 concentration data is also shown in the table. The inventories were calculated by multiplying each of the average analyte concentrations by 1.73 g/mL (the waste density as stated by Agnew et al. [1997a]) and 45,400 L (the waste volume). The HDW Model density is used in the calculation because an analytically-determined value does not exist for either tank 241-SX-115 or 241-SX-108.

Table D3-3. Proposed Inventory of Tank 241-SX-115 Based on Tank 241-SX-108 Data. (2 sheets)

Analyte	241-SX-108 Auger 95-AUG-043[1]	Inventory for Tank 241-SX-115 Based on Tank 241-SX-108 Data[2]
Nonradioactive Constituents	**µg/g**	**kg**
Al	52,300	4,110
Bi	55.6	4.37
Ca	2,630	207
Cl	2,680	211
Cr	10,200	801
F	687	54.0
Fe	25,500	2,000
Hg	n/r	n/r
K	933	73.3
La	180	14.1
Mn	8,940	702
Na	1.53E+05	12,000
Ni	1,750	137
NO_2	11,000	864
NO_3	1.73E+05	13,600
P	113	8.88
Pb	350	27.5
PO_4	<1,240	<97.4
S	1,170	91.9
Si	1,630	128
SO_4	4,550	357
Sr	833	65.4
TIC as CO_3	n/r	n/r
TOC	1,680[3]	132
U	7,610	598
Zr	636	50.0
Density (g/ml)	n/r	n/r

Table D3-3. Proposed Inventory of Tank 241-SX-115 Based on Tank 241-SX-108 Data. (2 sheets)

Analyte	241-SX-108 Auger 95-AUG-043[1]	Inventory for Tank 241-SX-115 Based on Tank 241-SX-108 Data[2]	
Nonradioactive Constituents	**µg/g**	**kg**	
^{60}Co	<1.66	<130	<163
$^{89/90}Sr$	4,670	3.67E+05	3.82E+05
$^{106}Ru/Rh$	<41.4	<3,250	<10,200
^{134}Cs	<1.97	<155	<271
^{137}Cs	199	15,600	16,300
^{154}Eu	<4.42	<347	<397
^{155}Eu	<8.89	<698	<880
^{226}Ra	<51.3	<4,030	<4,030

Notes:

n/r = not reported

[1]Hendrickson (1998), Appendix A

[2]Derived using the tank 241-SX-108 analytical data, the HDW Model density estimate of 1.73 g/mL, and a waste volume of 45.4 kL (12 kgal).

[3]Based on the lower half sample only (not analyzed on the upper half sample).

D3.3.2 Inventory Comparisons

Table D3-4 presents a comparison of the various inventory estimates for tank 241-SX-115, including the 1975 and 1998 sampling data, the previous best-basis estimates, the HDW Model estimates, and the estimates based on tank 241-SX-108 data. The HDW model inventory predictions for tank 241-SX-115 were made on the basis that the solids now in the tank originated from REDOX process HLW and REDOX process saltcake. The other two inventory estimates listed in Table D3-4 were made on the basis that solids in the tank originated solely from REDOX process HLW. This difference in prediction bases should always be kept in mind when comparing HDW model predictions to the independent assessment values.

Table D3-4. Tank 241-SX-115 Inventory Comparison. (2 sheets)

Analyte	Tank 241-SX-115 Inventory Based on 241-SX-108 Data[1,2]	Tank 241-SX-115 Sampling Data	Previous Best-Basis Inventory[3]	HDW Model[4] Inventory for Tank 241-SX-115
Nonradioactive Constituents	**kg**	**Kg**	**kg**	**kg**
Al	4,110	3,860[5]	7,890	6,360
Bi	4.37	n/r	3.33	0.0326
Ca	207	619[5]	21.1	270
Cl	211	n/r	187	149
Cr	801	n/r	151	1,040
F	54.0	n/r	9.46	0.153
Fe	2,000	4,160[5]	127	1,310
Hg	n/r	n/r	0	0.00492
K	73.3	n/r	34.0	38.4
La	14.1	n/r	0	5.34E-08
Mn	702	998[5]	105	0.0624
Na	12,000	2,000[5]	7,710	11,300
Ni	137	n/r	9.3	87.7
NO_2	864	167[5]	2,400	3,480
NO_3	13,600	n/r	9,660	14,800
Pb	27.5	n/r	2.62	0.805
PO_4	27.2[6]	<819[5]	136	0.959
Si	128	765[5]	98.5	88.1
SO_4	357	n/r	117	111
Sr	65.4	n/r	33.0	0
TIC as CO_3	n/r	n/r	326	411
TOC	132[7]	<88.0[8]	136	2.04
U	598	n/r	606	82.7
Zr	50.0	n/r	5.27	0.00142
Density	n/r	n/r	1.77 g/mL	1.73 g/mL
Radioactive Constituents[9]	**Ci**	**Ci**	**Ci**	**Ci**
^{60}Co	<163	122	(used HDW value)	0.254
$^{89/90}Sr$	3.82E+05	1.39E+06[5]	22,700	27,000
$^{106}Ru/Rh$	<10,200	n/r	(used HDW value)	5.41E-05

Table D3-4. Tank 241-SX-115 Inventory Comparison. (2 sheets)

Analyte	Tank 241-SX-115 Inventory Based on 241-SX-108 Data[1,2]	Tank 241-SX-115 Sampling Data	Previous Best-Basis Inventory[3]	HDW Model[4] Inventory for Tank 241-SX-115
Radioactive Constituents[9] (Cont'd)	**Ci**	**Ci**	**Ci**	**Ci**
^{125}Sb	n/r	172	(used HDW value)	0.865
^{134}Cs	<271	3.32	(used HDW value)	0.0529
^{137}Cs	16,300	2,070[5]	6,110	8,630
^{154}Eu	<397	920	(used HDW value)	6.08
^{155}Eu	<880	n/r	(used HDW value)	17.7
^{226}Ra	<4,030	n/r	(used HDW value)	3.52E-05
$^{239/240}Pu$	n/r	1,560[8]	(used HDW value)	14.2
^{241}Am	N/r	1,110[8]	(used HDW value)	2.83

Notes:

[1]Hendrickson (1998)

[2]Derived using the tank 241-SX-108 analytical data, the HDW density estimate of 1.73 g/mL, and a waste volume of 45.4 kL (12 kgal).

[3]Based on an average of data from tanks 241-S-101 (Kruger et al. [1996]), 241-S-104 (DiCenso et al. [1994]), and 241-S-107 (Simpson et al. [1996]). As described in Hendrickson (1998), only segments 7 upper through 8 lower were used for tank 241-S-101, the total sludge concentration was used for tank 241-S-104, and only the statistically determined median R1 sludge concentrations contained in the attachment to Simpson et al. (1996) were used for tank 241-S-107.

[4]Agnew et al. (1997a)

[5]1975 sampling data (Horton 1975)

[6]Derived from ICP phosphorus value from Table D3-3.

[7]Based on the lower half sample only (not analyzed on the upper half sample).

[8]1998 sampling data (Esch 1998)

[9]Radionuclides decayed to January 1, 1994.

Unique or notable observations from the inventory comparisons are provided below on an analyte basis. Most of the analytes discussed are those common to all four data sets.

Aluminum. All four of the aluminum inventory estimates are within the same order of magnitude. The best agreement with the tank 241-SX-115 analytical value was found with the tank 241-SX-108 data. The RPD between these two values was only 6.5 percent.

Calcium. The tank 241-SX-115 value was over two times larger than any of the other values. The HDW Model value was slightly closer to the tank 241-SX-115 number than the tank 241-SX-108 data. All estimates were at least an order of magnitude greater than the previous best-basis figure.

Hydroxide. Once the best-basis inventories were determined, the hydroxide inventory was calculated by performing a change balance with the valences of other analytes. This charge balance approach is consistent with that used by Agnew et al. (1997a).

Iron. The tank 241-SX-115 value was two times larger than the tank 241-SX-108 number, three times larger than the HDW Model value, and over 30 times greater than the previous best-basis estimate. The analytical iron value (4,160 kg) was also larger than the value predicted from the flow sheet calculations (829 kg) (see Section D3.3.3). According to the flow sheets, a maximum of only 1,548 kg of iron were placed in the tank, nearly 2.7 times below the measured value.

Manganese. Good agreement was observed between the tank 241-SX-115 and tank 241-SX-108 data. These values had an RPD of 35 percent. The previous best-basis estimate was only one-tenth of the analytical value, while the HDW Model value was four orders of magnitude less. The reason for the low HDW Model value is unknown, but likely reflects an incorrect calculation or an erroneous assumption about the solubility of manganese. Manganese would surely have precipitated when R waste was made alkaline. The flow sheets both listed a value of 0.0034 *M*, which may have even been biased low because of the omission of $KMnO_4$ in the published version of flow sheet No. 6. The estimated amount of manganese deposited in the tank based on the flow sheets was 371 kg, with a maximum value of 694 (see Section D3.3.3). This maximum value was 1.4 times below the tank 241-SX-115 analytical value.

Nitrite. Poor agreement was observed between the tank 241-SX-115 analytical value and the other inventory estimates. The closest value was the tank 241-SX-108 data, which was five times greater. The other values were approximately 14 and 20 times the analytical value. The RSltCk is expected to have a higher nitrite content than R sludge, so the expected nitrite content of the HDW Model would be higher.

Silicon. Tank 241-SX-115 contains significantly higher silicon that would be expected from the other inventory estimates. The 1975 analytical value was 763 kg, while the other estimates all ranged around 100 kg. The tank 241-SX-108 number was the closest to the 763 kg value.

Sodium. The tank 241-SX-115 analytical value was the smallest of the sodium estimates, providing further evidence that the tank does not contain saltcake (which has a higher sodium content). However, poor agreement was observed with the tank 241-SX-108 data, differing by a factor of six. None of the other estimates compared well either, although the HDW Model value would be expected to be biased high because half of the waste was projected to be saltcake.

The 1975 sodium value is low enough that there are questions regarding its validity. For a tank with R waste to have such a low sodium content, the waste would have had to have been sluiced or washed in some way to remove a portion of the soluble constituents. No such activity is known to have occurred for tank 241-SX-115. The sodium result from 1975 would also be abnormally low considering the nitrate content (which is generally expected to be present in about the same molar ratio as the sodium).

Cesium-137. The tank 241-SX-115 analytical value was less than any of the other predictions. The worst agreement was observed with the tank 241-SX-108 data, which was about eight times the tank 241-SX-115 number. None of the other numbers compared well, with the previous best-basis estimate being the closest at three times the 1975 analytical result.

Cobalt-60. The ^{60}Co comparison is notable because of the exceptionally high result from the 1975 sample. This result is significantly higher than observed for any other tank in the 200 West Area or any other tank containing REDOX sludge. Unfortunately, a good comparison was not available with the tank 241-SX-108 data.

Strontium-89/90. The 1975 tank 241-SX-115 analytical value was quite high. In fact, the result would indicate that the tank contains the second highest $^{89/90}Sr$ content on the Hanford Site. Although a substantial $^{89/90}Sr$ content is expected because the waste self-boiled, the 1975 result is high enough that it is considered suspect. Unfortunately, temperature data is not available for this tank to either support or discredit the 1975 value. The tank 241-SX-108 data appeared more reasonable. The previous best-basis and HDW estimates were extraordinarily low for a tank that self-boiled, and are considered unreliable. Although the 1998 samples were not analyzed for $^{89/90}Sr$, they displayed high beta activity. Seventeen days after extrusion, the glass of the sample jars began to darken, indicating high beta activity.

The comparisons raise some serious questions about the 1975 data. For many of the analytes, the 1975 results were substantially different from data obtained from tanks that contain similar waste types and process histories. Because details surrounding the 1975 sampling and analysis event are not available, one can only speculate on the reasons for the differences. The large differences may have been caused by analytical measurement error, or they could be a result of spatial bias and irregularities in the waste. For $^{89/90}Sr$ and ^{60}Co, the 1975 results would unexpectedly place this tank in the top few with the highest concentrations across the Hanford Site.

D3.3.3 Alternative Calculation Method for Inventory of Analytes Assumed to Completely Precipitate

Inventories of iron, manganese, bismuth, and uranium added to tank 241-SX-115 were calculated separately for the following years: 1958, 1959, and 1960. These calculations utilized data presented in Tables D3-1 and D3-2. Inventories (kg) of each analyte were calculated as the product of the following factors:

- Volume (kgal) of waste slurry added to tank in the respective times periods (Table D3-1)
- Molarity of analyte in waste stream (Table D3-2)
- Atomic weight of analyte (g)
- 1.0 E+03 gal/kgal--conversion factor
- 3.785 L/gal--conversion factor
- kg/1.0 E+03 g--conversion factor

Results of these calculations are summarized below; in all cases, quantities are given as kg.

1958

Iron: 145 kgal x 0.0074 mole/L x 3.785 L/gal x 1.0 E+03 gal/kgal x kg/1.0 E+03 g x 55.85 g/mole = 227 kg

Manganese: 103 kg

Uranium 483 kg

1959

Iron: 226 kgal x 0.0074 mole/L x 3.785 L/gal x 1.0 E+03 gal/kgal x kg/1.0 E+03 g x 55.85 g/mole = 354 kg

Manganese: 160 kg

Uranium: 753 kg

1960

Iron: 610 kgal x 0.0075 mole/L x 3.785 L/gal x 1.0 E+03 gal/kgal x kg/1.0 E+03 g x 55.85 g/mole = 967 kg

Bismuth: 23.6 kg

Uranium: 368 kg

Manganese: 431 kg

Total inventories of precipitable metals calculated by the alternate inventory determination method are:

Iron: 1,548 kg

Bismuth: 23.6 kg

Manganese: 694 kg

Uranium: 1,604 kg

However, these totals are for all the iron, bismuth, manganese, and uranium added to tank 241-SX-115. As noted earlier, 39.44 kL (10.42 kgal) of solid sludge appears to have redissolved or been resuspended, and was subsequently pumped out during transfers from the tank. Taking this loss into account, only a fraction of 12/22.42 of the original solids remain, or:

Iron: 829 kg

Bismuth: 12.6 kg

Manganese: 371 kg

Uranium: 859 kg

When compared with the estimates based on the tank 241-SX-108 waste, reasonable agreement is observed for the four metals. The bismuth and uranium flow sheet values are about 3 and 1.5 imes their respective tank 241-SX-108 estimates. The iron and manganese estimates differ by approximate factors of 2.5 and 2; however, it is the tank 241-SX-108 results that are higher.

The 1975 analytical results from tank 241-SX-115 for iron (4,160 kg) and manganese (999 kg) are even higher than the tank 241-SX-108 data. Taking into account the maximum amount of these metals that could have entered the tank based on the flow sheets, the 1975 analytical results are still approximately 2.7 times higher for iron and 1.5 times higher for manganese. The fact that flow sheet-based estimates for two of the four analytes are less than the tank 241-SX-115 and 241-SX-108 analytical values, indicates either a faulty assumption or a problem with the flow sheets. The likely explanation is a problem with the assumption that the partitioning of the insoluble constituents occurred according to a 12/22.42 ratio with the total amount of species in the REDOX HLW waste streams. The analytical data implies that more of the insoluble components remained in the tank.

D4.0 DEFINE THE BEST-BASIS AND ESTABLISH COMPONENT INVENTORIES

Tank farm activities include overseeing tank farm operations and identifying, monitoring, and resolving safety issues associated with these operations and with the tank wastes. Disposal activities involve designing equipment, processes, and facilities for retrieving wastes and processing them into a form that is suitable for long-term storage/disposal. Information about chemical, radiological, and/or physical properties is used to perform safety analyses, engineering evaluations, and risk assessment work associated with tank farm operation and disposal.

Chemical and radiological inventory information are generally derived using three approaches: 1) component inventories are estimated using the results of sample analyses, 2) component inventories are predicted using the HDW Model based on process knowledge and historical information, or (3) a tank-specific process estimate is made based on process flow sheets, reactor fuel data, essential material usage, and other operating data.

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of chemical information for tank 241-SX-115 was performed, and a best basis inventory was established. This work follows the methodology that was established by the standard inventory task. The following information was utilized as part of this evaluation:

- Limited analytical results from a 1975 sludge sampling (Horton 1975)
- Limited analytical results from the 1998 finger trap grab sampling (Esch 1998)
- Inventory estimates generated by HDW model (Agnew et al. 1997a)

- Average of analyte concentrations in REDOX process HLW for auger 95-AUG-043 from tank 241-SX-108 (Hendrickson 1998)

- Average of analyte concentrations in REDOX process HLW sludges in tanks 241-S-101 (Kruger et al. 1996), 241-S-104 (DiCenso et al. 1994), and 241-S-107 (Simpson et al. 1996)

- Inventory estimates generated by a tank-specific assessment process utilizing chemical process flow sheets and a detailed historical waste transaction data base.

Because the vast majority of the waste constituents were not analyzed on the 1998 samples, an alternative method of deriving inventories was required. The results from the evaluation presented in this appendix support using a predicted inventory based primarily on data from auger 95-AUG-043 of tank 241-SX-108 for the following reasons:

1. Based upon a comprehensive review of historical waste transaction records, it is believed that only the REDOX process HLW introduced into tank 241-SX-115 contributed to the solid waste currently in the tank.

2. The HDW model incorrectly attributes part of the solids now in tank 241-SX-115 to saltcake precipitated from one addition of concentrated REDOX process HLW supernatant.

3. Many uncertainties exist regarding the quality of the 1975 data for tank 241-SX-115.

4. The waste in tank 241-SX-108 originated from the same REDOX processes as that in tank 241-SX-115, and both tanks shared similar process histories (self-boiling). The analytical data from auger 95-AUG-043 of tank 241-SX-108 more closely matches the available tank 241-SX-115 analytical values than the previous best-basis estimates or the HDW Model values.

For the few analytes that had results from the 1975 sample but no corresponding tank 241-SX-108 data, the 1975 values were used to derive the inventory. Model numbers were used when there were no analytical values, or the analytical values were large non-detects.

Best-basis tank inventory values are derived for 46 key radionuclides (as defined in Section 3.1 of Kupfer et al. 1998), all decayed to a common report date of January 1, 1994. Often, waste sample analyses have only reported ^{90}Sr, ^{137}Cs, $^{239/240}$Pu, and total uranium (or total beta and total alpha), while other key radionuclides such as ^{60}Co, ^{99}Tc, ^{129}I, ^{154}Eu, ^{155}Eu, and ^{241}Am, etc., have been infrequently reported. For this reason, it has been necessary to derive most of the 46 key radionuclides by computer models. These models estimate radionuclide activity in batches of reactor fuel, account for the split of radionuclides to various separations plant waste streams, and track their movement with tank waste transactions. (These computer models are described in Kupfer et al. 1998, Section 6.1 and in Watrous and Wootan 1997.) Model generated values for radionuclides in any of 177 tanks are reported in the HDW Rev. 4 model results (Agnew et al. 1997a). The best-basis value for any one analyte may be either a model result or a sample or engineering assessment-based result, if available.

The inventory values reported in Tables D4-1 and D4-2 are subject to change. Refer to the Tank Characterization Database (LMHC 1999) for the most current inventory values.

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-SX-115 (Effective January 20, 1999). (2 sheets)

Analyte	Total Inventory (kg)	Basis (S, M, E, or C)[1]	Comment
Al	4,110	E	Horton (1975) = 3,860 kg
Bi	4.37	E	
Ca	207	E	Horton (1975) = 619 kg
Cl	211	E	
TIC as CO_3	411	M	
Cr	801	E	
F	54.0	E	
Fe	2,000	E	Horton (1975) = 4,160 kg
Hg	0	E	Simpson 1998
K	73.3	E	
La	14.1	E	
Mn	702	E	Horton (1975) = 998 kg
Na	12,000	E	Horton (1975) = 2,000 kg
Ni	137	E	
NO_2	864	E	Horton (1975) = 167 kg
NO_3	13,600	E	
OH_{TOTAL}	16,000	C	
Pb	27.5	E	
PO_4	27.2	E	Based on ICP
Si	128	E	Horton (1975) = 765 kg
SO_4	357	E	Based on IC
Sr	65.4	E	

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-SX-115 (Effective January 20, 1999). (2 sheets)

Analyte	Total Inventory (kg)	Basis (S, M, E, or C)[1]	Comment
TOC	88.0	S/E	Upper bounding estimate; 1998 result
U_{TOTAL}	598	E	
Zr	50.0	E	

Note:

[1]S = Sample-based; M = HDW model-based (Agnew et al. [1997a]); E = Engineering assessment-based; C = Calculated by charge balance; includes oxides as hydroxides, not including CO_3, NO_2, NO_3, PO_4, SO_4, and SiO_3.

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-SX-115 Decayed to January 1, 1994 (Effective January 20, 1999). (3 sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{3}H	5.73	M	
^{14}C	0.311	M	
^{59}Ni	0.492	M	
^{60}Co	122	S	Horton (1975)
^{63}Ni	46.5	M	
^{79}Se	0.169	M	
^{90}Sr	3.82E+05	E	Horton (1975) = 1.39E+06 Ci
^{90}Y	3.82E+05	E	Referenced to ^{90}Sr
^{93}Zr	0.798	M	
^{93m}Nb	0.648	M	
^{99}Tc	2.38	M	
^{106}Ru	5.41E-05	M	
^{113m}Cd	1.21	M	
^{125}Sb	172	S	Horton (1975)
^{126}Sn	0.259	M	
^{129}I	0.00452	M	
^{134}Cs	3.32	S	Horton (1975)

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-SX-115 Decayed to January 1, 1994 (Effective January 20, 1999). (3 sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{137}Cs	16,300	E	Horton (1975) = 2,070 Ci
^{137m}Ba	15,400	E	Referenced to ^{137}Cs
^{151}Sm	602	M	
^{152}Eu	0.360	M	
^{154}Eu	920	S	Horton (1975)
^{155}Eu	880	E	Upper bounding estimate; Based on tank 241-SX-108 data
^{226}Ra	3.52E-05	M	
^{227}Ac	1.71E-04	M	
^{228}Ra	3.58E-04	M	
^{229}Th	8.62E-06	M	
^{231}Pa	2.51E-04	M	
^{232}Th	4.79E-06	M	
^{232}U	0.0116	E/M	Based on total uranium and HDW isotopic distribution
^{233}U	0.0442	E/M	Based on total uranium and HDW isotopic distribution
^{234}U	0.228	E/M	Based on total uranium and HDW isotopic distribution
^{235}U	0.00928	E/M	Based on total uranium and HDW isotopic distribution
^{236}U	0.00896	E/M	Based on total uranium and HDW isotopic distribution
^{237}Np	0.0111	M	
^{238}Pu	22.3	S/M	Based on ^{239}Pu data and HDW isotopic distribution
^{238}U	0.200	E/M	Based on total uranium and HDW isotopic distribution
^{239}Pu	1,360	S/M	Based on 1998 $^{239/240}Pu$ data and HDW isotopic distribution
^{240}Pu	199	S/M	Based on 1998 $^{239/240}Pu$ data and HDW isotopic distribution
^{241}Am	1,110	S	1998 result
^{241}Pu	1,290	S/M	Based on ^{239}Pu data and HDW isotopic distribution
^{242}Cm	1.45	S/M	Based on ^{241}Am data and HDW isotopic distribution

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-SX-115 Decayed to January 1, 1994 (Effective January 20, 1999). (3 sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{242}Pu	0.00612	S/M	Based on ^{239}Pu data and HDW isotopic distribution
^{243}Am	0.0338	S/M	Based on ^{241}Am data and HDW isotopic distribution
^{243}Cm	0.0331	S/M	Based on ^{241}Am data and HDW isotopic distribution
^{244}Cm	0.0257	S/M	Based on ^{241}Am data and HDW isotopic distribution

Note:

[1]S = Sample-based; M = HDW model-based (Agnew et al. [1997a]); E = Engineering assessment-based

D5.0 APPENDIX D REFERENCES

Agnew, S. F., J. Boyer, R. A. Corbin, T. B. Duran, J. R. FitzPatrick, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1997a, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 4*, LA-UR-96-3860, Los Alamos National Laboratory, Los Alamos, New Mexico.

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DiCenso, A. T., L. C. Amato, J. D. Franklin, G. L. Nuttall, K. W. Johnson, P. Sathyanarayana, and B. C. Simpson, 1994, *Tank Characterization Report for Single-Shell Tank 241-S-104*, WHC-SD-WM-ER-370, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Esch, R. A., 1998, *Tank 241-SX-115, Grab Samples 15SX-98-1, 15SX-98-2, and 15SX-98-3 Analytical Results for the Final Report*, HNF-SD-WM-DP-304, Rev. 0, Waste Management Federal Services of Hanford, Inc. for Fluor Daniel Hanford, Inc., Richland, Washington.

Hanlon, B. M., 1999, *Waste Tank Summary Report for Month Ending November 30, 1998*, WHC-EP-0182-128, Westinghouse Hanford Company, Richland, Washington.

Hendrickson, D. W., 1998, *Tank Characterization Report for Single-Shell Tank 241-SX-108*, WHC-SD-WM-ER-582, Rev. 0B, COGEMA Engineering Corporation, Richland for Fluor Daniel Hanford, Inc., Richland, Washington.

Hodgson, K. M., and M. D. LeClair, 1996, *Work Plan for Defining a Standard Inventory Estimate for Wastes Stored in Hanford Site Underground Tanks*, WHC-SD-WM-WP-311, Rev. 1, Lockheed Martin Hanford Corp., for Fluor Daniel Hanford, Inc., Richland, Washington.

Horton, J. E., 1975, *Analysis of Tank 115-SX Sludge Sample*, (internal letter to W. R. Christensen, April 22), Atlantic Richfield Hanford Company, Richland, Washington.

Kupfer, M. J., A. L. Boldt, B. A. Higley, K. M. Hodgson, L. W. Shelton, B. C. Simpson, R. A. Watrous, S. L. Lambert, D. E. Place, R. M. Orme, G. L. Borsheim, N. G. Colton, M. D. LeClair, R. T. Winward, and W. W. Schulz, 1998, *Standard Inventories of Chemicals and Radionuclides in Hanford Site Tank Wastes*, HNF-SD-WM-TI-740, Rev. 0B, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

Kruger, A. A., B. J. Morris, and L. J. Fergestrom, 1996, *Tank Characterization Report for Single-Shell Tank 241-S-101*, WHC-SD-WM-ER-613, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

LMHC, 1999, *Best-Basis Inventory for Tank 241-SX-115*, Tank Characterization Database, Internet at http://twins.pnl.gov:8001/TCD/main.html.

Simpson, B. C., J. G. Field, D. W. Engel, and D. S. Daly, 1996, *Tank Characterization Report for Single-Shell Tank 241-S-107*, WHC-SD-WM-ER-589, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Simpson, B. C., 1998, *Best Basis Inventory Change Package for Reconciliation of Mercury Values, Change Package No. 7*, (internal memorandum 7A120-98-005 to J. W. Cammann, February 26), Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

Swaney, S. L., 1993, *Waste Level Discrepancies Between Manual Level Readings and Current Waste Inventory for Single-Shell Tanks,* (internal memorandum 7624-93-058 to G. T. Frater, December 10), Westinghouse Hanford Company, Richland, Washington.

Watrous, R. A., and D. W. Wootan, 1997, *Activity of Fuel Batches Processed Through Hanford Separations Plants, 1994 through 1989*, HNF-SD-WM-TI-794, Rev. 0, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

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APPENDIX E

BIBLIOGRAPHY FOR TANK 241-SX-115

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APPENDIX E

BIBLIOGRAPHY FOR TANK 241-SX-115

Appendix E is a bibliography that supports the characterization of tank 241-SX-115. This bibliography represents an in-depth literature search of all known information sources that provide sampling, analysis, surveillance, modeling information, and processing occurrences associated with tank 241-SX-115 and its respective waste types.

The references in this bibliography are separated into three categories containing references broken down into subgroups. These categories and their subgroups are listed below.

I. NON-ANALYTICAL DATA

- Ia. Models/Waste Type Inventories/Campaign Information
- Ib. Fill History/Waste Transfer Records
- Ic. Surveillance/Tank Configuration
- Id. Sample Planning/Tank Prioritization
- Ie. Data Quality Objectives/Customers of Characterization Data

II. ANALYTICAL DATA - SAMPLING OF TANK WASTE AND WASTE TYPES

- IIa. Sampling of Tank 241-SX-115
- IIb. Sampling of Similar Waste Types

III. COMBINED ANALYTICAL/NON-ANALYTICAL DATA

- IIIa. Inventories Using Both Campaign and Analytical Information
- IIIb. Compendium of Existing Physical and Chemical Documented Data Sources

This bibliography is broken down into the appropriate sections of material with an annotation at the end of each reference describing the information source. Most information listed below is available in the Lockheed Martin Hanford Corporation Tank Characterization and Safety Resource Center.

I. NON-ANALYTICAL DATA

Ia. Models/Waste Type Inventories/Campaign Information

Anderson, J. D., 1990, *A History of the 200 Area Tank Farms*, WHC-MR-0132, Westinghouse Hanford Company, Richland, Washington.

- Contains single-shell tank fill history and primary campaign and waste information to 1981.

Jungfleisch, F. M., and B. C. Simpson, 1993, *Preliminary Estimation of the Waste Inventories in Hanford Tanks Through 1980*, WHC-SD-WM-TI-057 Rev. 0A, Westinghouse Hanford Company, Richland, Washington.

- A model based on process knowledge and radioactive decay estimations using ORIGEN for different compositions of process waste streams assembled for total, solution, and solids compositions per tank. Assumptions about waste/waste types and solubility parameters and constraints are also given.

Ib. Fill History/Waste Transfer Records

Agnew, S. F., R. A. Corbin, T. B. Duran, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1997, *Waste Status and Transaction Record Summary (WSTRS) Rev. 4*, LA-UR-97-311, Rev. 0, Los Alamos National Laboratory, Los Alamos, New Mexico.

- Contains spreadsheets showing all available data on tank additions and transfers.

Anderson, J. D., 1990, *A History of the 200 Area Tank Farms*, WHC-MR-0132, Westinghouse Hanford Company, Richland, Washington.

- Contains single-shell tank fill history and primary campaign and waste information to 1981.

Ic. Surveillance/Tank Configuration

Alstad, A. T., 1993, *Riser Configuration Document for Single-Shell Waste Tanks*, WHC-SD-RE-TI-053, Rev. 9, Westinghouse Hanford Company, Richland, Washington.

- Shows tank riser locations in relation to a tank aerial view and describes the risers and their contents.

Bailey, J. W., 1978, *Tank Status Update*, (internal memorandum 60412-78-0434 to Distribution, October 2), Rockwell Hanford Operations, Richland, Washington.

- Updates the status for tank 241-SX-115 to reflect a change from primary stabilized to interim stabilized.

DeFigh-Price, C., 1981, *Waste Tank 241-SX-115 Core Drilling Results*, RHO-CD-1538, Rockwell Hanford Operations, Richland, Washington.

- Contains observations and a day-by-day account of drilling operations performed to obtain core samples of the concrete load bearing areas (hauch, wall, and footing) of tank 241-SX-115.

Gillen, M.P., 1982, *Strength and Elastic Properties, Tests of Hanford Concrete Cores 241-SX-115 Tank and 202-A PUREX Canyon Building,* RHO-RE-CR-2, Portland Cement Association for Rockwell Hanford Operations, Richland Washington.

- Contains results of material property tests concrete cores performed on load supporting concrete (haunch and wall) from tank 241-SX-115 and PUREX as an ongoing effort to evaluate storage tanks.

Lipnicki, J., 1997, *Waste Tank Risers Available for Sampling*, HNF-SD-RE-TI-710, Rev. 4, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Assesses riser locations for each tank; however, not all tanks are included or completed. The risers believed to be available for sampling are also included.

Neilsen, E. H., 1992, *Tank 241-SX-115 Supporting Documentation*, WHC-MR-0302, (Supplement 1 to *Tank 241-SX-115 Leak Assessment*), Westinghouse Hanford Company, Richland, Washington.

- Contains internal memoranda, reports, and letters used to support a leak assessment. Information presented includes waste status reports, historical lateral scans, and analytical data.

Tran, T. T., 1993, *Thermocouple Status Single-Shell & Double-Shell Waste Tanks*, WHC-SD-WM-TI-553, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Contains riser and thermocouple information for Hanford Site waste tanks.

Welty, R. K, 1988, *Waste Storage Tank Status and Leak Detection Criteria*, WHC-SD-WM-TI-356, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Presents liquid level, dry well, and leak detection pit surveillance data along with a tank status summary.

WHC, 1992, *Tank 241-SX-115 Leak Assessment*, WHC-MR-0302, Westinghouse Hanford Company, Richland, Washington.

- Reviews all previous leak assessments and any additional available data to develop an updated leakage assessment.

Id. Sample Planning/Tank Prioritization

Brown, T. M., S. J. Eberlein, J. W. Hunt, and L. J. Fergestrom, 1997, *Tank Characterization Technical Sampling Basis*, HNF-SD-WM-TA-164, Rev. 3, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Summarizes the 1997 technical basis for characterizing tank waste and assigns a priority number to each tank.

Brown, T. M., S. J. Eberlein, J. W. Hunt, and L. J. Fergestrom, 1998, *Tank Characterization Technical Sampling Basis*, HNF-SD-WM-TA-164, Rev. 4, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Summarizes the 1998 technical basis for characterizing tank waste and assigns a priority number to each tank.

DOE-RL, 1996, *Recommendation 93-5 Implementation Plan*, DOE/RL-94-0001, Rev. 1, U.S. Department of Energy, Richland, Washington.

- Describes the organic solvents issue and other tank issues.

Grimes, G. W., 1977, *Hanford Long-Term Defense High-Level Waste Management Program Waste Sampling and Characterization Plan*, RHO-CD-137, Rockwell Hanford Operations, Richland, Washington.

- Early characterization planning document.

Homi, C. S., 1996, *Tank 241-SX-115 Tank Characterization Plan*, WHC-SD-WM-TP-325, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

- Identified the information needed to address relevant safety issues for tank 241-SX-115. No sampling was performed as a result of this plan.

Sasaki, L. M., 1995, *Tank 241-SX-115 Tank Characterization Plan*, WHC-SD-WM-TP-325, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Details sampling and analysis requirements (based on applicable DQOs) for a 1995 auger sampling event. No analyses were performed on the augers because of a lack of sample material.

Simpson, B. C., 1996, *Tank 241-SX-115 Auger Sampling and Analysis Plan*, WHC-SD-WM-TSAP-090, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Contains the sampling and analytical plan for a proposed 1996 auger sampling event. No samples were actually taken.

Simpson, B. C., 1998, *Tank 241-SX-115 Grab Sampling and Analysis Plan*, HNF-2250, Rev. 0, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Identifies the sampling and analytical plan for the 1998 grab samples.

Simpson, B. C., 1998, *Modifications to 241-SX-115 Sample Handling and Analysis*, (internal memorandum 7A120-98-013 to R. A. Esch, April 6), Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Contains changes made to the analytical plan for the 1998 grab samples based on experience gained in dealing with the 1997 auger samples from tank 241-AX-104.

Stanton, G. A., 1998, *Baseline Sampling Schedule, Change 98-03*, (internal memorandum 79520-98-003 to distribution, October 25), Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Provides a tank waste sampling schedule through fiscal year 2004 and list samples taken since 1994.

Winkelman, W. D., M. R. Adams, T. M. Brown, J. W. Hunt, D. J. McCain, and L. S. Fergestrom, 1997, *Fiscal Year 1997-1998 Waste Information Requirements Document*, HNF-SD-WM-PLN-126, Rev. 0A, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Contains Tri-Party Agreement (Ecology et al. 1996) requirement-driven TWRS Characterization Program information.

Ie. Data Quality Objectives and Customers of Characterization Data

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- Determines whether tanks are under safe operating conditions.

Meacham, J. E., D. L. Banning, M. R. Allen, and L. D. Muhlestein, 1997, *Data Quality Objective to Support Resolution of the Organic Solvent Safety Issue*, HNF-SD-WM-DQO-026, Rev. 0, DE&S Hanford, Inc. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Contains requirements for the organic solvents DQO.

Osborne, J. W., and L. L. Buckley, 1995, *Data Quality Objectives for Tank Hazardous Vapor Safety Screening*, WHC-SD-WM-DQO-002, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

- Contains requirements for addressing hazardous vapor issues.

Schreiber, R. D., 1997, *Memorandum of Understanding for the Organic Complexant Safety Issue Data Requirements*, HNF-SD-WM-RD-060, Rev. 0, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Contains requirements, methodology, and logic for analyses to support organic complexant issue resolution.

Owendoff, J. M., 1998, *Approval to Close the Organic Complexant Safety Issue and Remove 18 Organic Complexant Tanks from the Watchlist,* (memorandum to J. Wagoner, December 9), U. S. Department of Energy, Washington, D. C.

- Contains requirements, methodology, and logic for analyses to support organic complexant issue resolution.

II. ANALYTICAL DATA - SAMPLING OF TANK WASTE AND WASTE TYPES

IIa. Sampling of Tank 241-SX-115

Esch, R. A., 1998, *Tank 241-SX-115, Grab Samples 15SX-98-1, 15SX-98-2, and 15SX-98-3 Analytical Results for the Final Report,* HNF-SD-WM-DP-304, Rev. 0, Waste Management Federal Services of Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

- Contains results from analyses of the 1998 grab samples.

Esch, R. A., 1998, *Safety Screening Analysis Results for the 45-Day Report - Tank 241-SX-115*, (letter WMH-9854084 to K. M. Hall, May 8), Waste Management Federal Services of Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

- Presents results for the safety screening analyses on the 1998 grab samples.

Horton, J. E., 1975, *Analysis of Tank 115-SX Sludge Sample*, (letter to W. R. Christensen, April 22), Atlantic Richfield Hanford Company, Richland, Washington.

- Presents analytical results for a March 1975 sludge sample.

Raymond, J. R., and E. G. Shdo, 1966, *Characterization of Subsurface Contamination in the SX Tank Farm*, BNWL-CC-701, Battelle Northwest, Richland, Washington.

- Presents analytical data for samples from tanks in the SX tank farm. For tank 241-SX-115, results are given for a September 1964 sample.

IIb. Sampling of Similar Waste Types

Eggers, R. F., J. D. Franklin, B. J. Morris, and T. T. Tran, 1996, *Tank Characterization Report for Single-Shell Tank 241-SX-108*, WHC-SD-WM-ER-582, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Contains characterization data for the waste in tank 241-SX-108, including R1 waste.

Hu, T. A., 1998, *Tank Characterization Report for Single-Shell Tank 241-SX-101*, HNF-SD-WM-ER-660, Rev. 1, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Contains characterization data for the waste in tank 241-SX-101, including RSltCk and R1 waste.

Jo, J., 1997, *Tank Characterization Report for Single-Shell Tank 241-S-104*, HNF-SD-WM-ER-370, Rev. 1A, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Contains characterization data for the waste in tank 241-S-104, including RSltCk and R1 waste.

Kruger, A. A., B. J. Morris, and L. J. Fergestrom, 1996, *Tank Characterization Report for Single-Shell Tank 241-S-101*, WHC-SD-WM-ER-613, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Contains characterization data for the waste in tank 241-S-101, including R1 waste.

Simpson, B. C, 1997, *Tank Characterization Report for Single-Shell Tank 241-S-107*, WHC-SD-WM-ER-589, Rev. 0A, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Contains characterization data for the waste in tank 241-S-107, including RSltCk and R1 waste.

III. COMBINED ANALYTICAL/NON-ANALYTICAL DATA

IIIa. Inventories Using Both Campaign and Analytical Information

Agnew, S. F., J. Boyer, R. A. Corbin, T. B. Duran, J. R. Fitzpatrick, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1997, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 4*, LA-UR-96-3860, Rev. 0, Los Alamos National Laboratory, Los Alamos, New Mexico.

- Contains waste type summaries and primary chemical compound/analyte and radionuclide estimates for sludge, supernatant, and solids

Allen, G. K., 1976, *Estimated Inventory of Chemicals Added to Underground Waste Tanks, 1944 - 1975*, ARH-CD-601B, Atlantic Richfield Hanford Company, Richland, Washington.

- Contains major components for waste types, and some assumptions. Purchase records are used to estimate chemical inventories.

Brevick, C. H., J. L. Stroup, and J. W. Funk, 1997, *Historical Tank Content Estimate for the Southwest Quadrant of the Hanford 200 East Area*, WHC-SD-WM-ER-352, Rev. 1, Fluor Daniel Northwest, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

- Contains summary information for tanks in the S, SX, and U Tank Farms, in-tank photo collages, and inventory estimates.

Harmsen, R. W., and W. W. Schulz, 1998, *Best Basis Estimates of Solubility of Selected Radionuclides in Sludges in Hanford SST*, HNF-3271, Rev. 0, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Provides authoritative Best-Basis estimates of solubility (fraction precipitated) of all the 46 radionuclides in the various wastes added to the SSTs and, hence, more reliable predictions by the HDW Model of the distribution of all radionuclide solubility among the 177 tanks.

Klem, M. J., 1990, *Total Organic Carbon Concentration of Single-Shell Tank Waste*, (internal memorandum 82316-90-032 to R. E. Raymond, April 27), Westinghouse Hanford Company, Richland, Washington.

- Provides a list of total organic carbon concentration for many tanks.

Klem, M. J., 1988, *Inventory of Chemicals Used at Hanford Production Plants and Support Operations (1944 – 1980)*, WHC-EP-0172, Westinghouse Hanford Company, Richland, Washington.

- Provides a list of chemicals used in production facilities and support operations that sent wastes to the single-shell tanks. The list is based on chemical process flowsheets, essential materials consumption records, letters, reports, and other historical data.

Kupfer, M. J., A. L. Boldt, and M. D. LeClair, 1998, *Standard Inventories of Chemicals and Radionuclides in Hanford Site Tank Wastes*, HNF-SD-WM-TI-740, Rev. 0B, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Contains a global component inventory for major constituents in the 200 Area waste tanks.

Toth, J. J., C. E. Willingham, P. G. Heasler, and P. D. Whitney, 1994, *Organic Carbon in Hanford Single-Shell Tank Waste*, PNL-9434, Pacific Northwest Laboratory, Richland, Washington.

- Contains organic carbon analytical results and model estimates for tanks.

IIb. Compendium of Existing Physical and Chemical Documented Data Sources

Brevick, C. H., J. L. Stroup, and J. W. Funk, 1997, *Supporting Document for the Historical Tank Content Estimate for SX-Tank Farm*, HNF-SD-WM-ER-324, Rev. 1, Fluor Daniel Northwest, Inc., Richland, Washington.

- Contains historical data and solid inventory estimates. The appendices contain level history AutoCAD sketches, temperature graphs, surface level graphs, cascade/dry well charts, riser configuration drawings and tables, in-tank photos, and tank layer model bar charts and spreadsheets.

Brevick, C. H., L. A.Gaddis, and J. W. Williams, 1996, *Historical Vadose Contamination of S and SX Tank Farms,* WHC-SD-WM-ER-560, Rev. 0, Kaiser Hanford Co. for Westinghouse Hanford Company, Richland, Washington.

- Provides a collection of historical information regarding contamination of the soil surface and vadose zone in the vicinity of the 241-S and 241-SX Tank Farms. Information is compiled about the S and SX Tank Farms and all known liquid radioactive waste disposal sites (cribs), unplanned releases, and monitoring wells within a 500-meter radius of the tank farms.

Brevick, C. H., L. A. Gaddis, and E. D. Johnson, 1995, *Tank Waste Source Term Inventory Validation, Vol I & II*, WHC-SD-WM-ER-400, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Contains a quick reference to sampling information in spreadsheet or graphical form for 23 chemicals and 11 radionuclides for all the tanks.

Hanlon, B. M., 1999, *Waste Tank Summary Report for Month Ending November 30, 1998*, HNF-EP-0182-128, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Contains a monthly summary of the following: fill volumes, Watch List tanks, occurrences, integrity information, equipment readings, equipment status, tank location, and other miscellaneous tank information.

Husa, E. I., 1993, *Hanford Site Waste Storage Tank Information Notebook*, WHC-EP-0625, Westinghouse Hanford Company, Richland, Washington.

- Contains in-tank photographs and summaries on the tank description, leak detection system, and tank status.

Husa, E. I., 1995, *Hanford Waste Tank Preliminary Dryness Evaluation*, WHC-SD-WM-TI-703, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Assesses relative dryness between tanks.

LMHC, 1998, *Tank Characterization Data Base*, Internet at http://twins.pnl.gov:8001/htbin/TCD/main.html

- Contains analytical data for each of the 177 Hanford Site waste tanks.

Swaney, S. L., 1993, *Waste Level Discrepancies Between Manual Level Readings and Current Waste Inventory for Single-Shell Tanks*, (Internal memorandum 7624-93-058 to G.T. Frater, December 10), Westinghouse Hanford Company, Richland, Washington.

- Contains information and explanations of discrepancies between manual measurements and estimated tank waste volumes.

Shelton, L. W., 1996, *Chemical and Radionuclide Inventory for Single- and Double-Shell Tanks*, (internal memorandum 74A20-96-30 to D. J. Washenfelder, February 28), Westinghouse Hanford Company, Richland, Washington.

- Contains a tank inventory estimate based on analytical information.

Van Vleet, R. J., 1993, *Radionuclide and Chemical Inventories*, WHC-SD-WM-TI-565, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

- Contains tank inventory information.

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Sandia National Laboratory P.O. Box 5800 MS-0744, Dept. 6404 Albuquerque, NM 87815					
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